Report

Preliminary Design Report Combe Fill South Landfill Superfund Site Remedial Design Ground Water Treatment Facility

New Jersey Department of Environmental Protection

May 1990

O'BRIEN & GERE

REPORT

PRELIMINARY DESIGN
COMBE FILL SOUTH LANDFILL
SUPERFUND SITE
GROUND WATER TREATMENT FACILITY

NEW JERSEY DEPARTMENT OF
ENVIRONMENTAL PROTECTION

MAY, 1990

O'BRIEN & GERE ENGINEERS, INC.
RARITAN PLAZA I
EDISON, NEW JERSEY 08837

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SECTION 1 - INTRODUCTION

1.01 Background

The Combe Fill South Landfill in Chester and Washington Townships, Morris County, New Jersey, has accepted municipal and industrial wastes since the 1940s. This inactive landfill consists of three separate disposal areas covering about sixty-five acres. Approximately five million cubic yards of waste material were buried within the Combe Fill South Landfill. The majority of the waste includes typical household waste and non-hazardous industrial waste. However, the presence of volatile organic compounds has been identified beneath the site within two ground water aquifers (shallow and deep). Some of these volatile organic compounds have been detected in samples collected from nearby potable residential wells.

The Combe Fill South Landfill site was listed on the National Priority List in September 1983. Subsequently, a Remedial Investigation/Feasibility Study (RI/FS) was conducted from 1984 through 1985 under the lead of the New Jersey Department of Environmental Protection (NJDEP). The Record of Decision (ROD) for this site has identified the following areas to be encompassed within the Remedial Design:

1. An active collection and treatment system for methane and any other landfill generated gases.
2. Expanded environmental monitoring of water, air, soils and leachate.
3. A multi-layered cap that covers the landfilled areas and extends under the utility company right-of-way.

4. Pumping and on-site treatment of shallow ground water with discharge to Trout Brook.
5. Surface water controls to accommodate runoff from both normal precipitation and severe storms.
6. Security fencing, an access road and general site preparation.

1.02 Authorization and Scope

In July 1987, NJDEP authorized O'Brien & Gere Engineers, Inc. to perform the work necessary to complete the Remedial Design of the Combe Fill South Landfill, as mandated within the ROD. The work is being conducted in accordance with the Scope of Services outlined within O'Brien & Gere's proposal to NJDEP dated July 1987. In order to optimize the schedule for completion of the design, NJDEP requested that two separate designs be developed for the site. Therefore, the design of the ground water treatment facility is being conducted separately from the remainder of the Remedial Design.

A report presenting the preliminary design of the cover system, the shallow ground water collection and conveyance system and the landfill gas system has previously been submitted. This report provides results of ground water treatability testing, as well as the preliminary basis of design of the on-site ground water treatment facility.

SECTION 2 - GROUND WATER CHARACTERISTICS AND TREATABILITY TESTING

2.01 Background

As previously stated, the ROD for the Combe Fill South Landfill (CFSL) identified a selected remedy, which among other items, includes the following components:

- An active collection and treatment system for landfill gases; and
- Pumping and on-site treatment of shallow ground water with discharge to Trout Brook.

Ground water will be collected by a series of ground water recovery wells. This recovered ground water will initially contain a component of "leachate", or water which has been directly exposed to landfilled materials. As the landfill installation proceeds to completion, and precipitation infiltration through the landfilled materials declines, the recovered ground water will decline in strength and volume.

The landfill gas collection and treatment system will generate a liquid waste stream formed by condensation of gas vapors. This condensate will be formed as a result of temperature differences between landfill gas and ambient air. The nature of condensate is such that treatment is required prior to discharge to receiving waters. Condensate generation and treatment at the site was not identified by the RI/FS report or in the ROD, nor was it anticipated in the ongoing remedial design RFP or contract. Landfill gas condensate has only recently been identified as an issue at the site.

Section 2 identifies known and estimated characteristics of ground water, and landfill gas condensate. Section 2 addresses treatability testing conducted on shallow aquifer ground water only. Landfill gas condensate treatability testing was not conducted, as the volume of landfill gas condensate produced from a small scale gas withdrawal test was insufficient to conduct reasonably scaled biological treatability studies (one liter of feed per day or greater). Treatment system components required to meet discharge requirements are recommended herein.

2.02 Objectives

The principal objective of the ground water treatability study was to provide a conceptual design for a system to treat ground water from the shallow aquifer beneath the Combe Fill South Landfill. The specific objectives of the ground water treatability study were to evaluate the efficiency and efficacy of:

1) chemical precipitation and subsequent settling of metals,
2) biological treatment of organics,
3) mixed media filtration for the removal of solids, and
4) air stripping and activated carbon polishing for removal of organics resistant to biological treatment.

Four unit operations sequences were evaluated in the treatability study (Figure 2-1).

2.03 Ground Water and Condensate Characteristics

The Remedial Investigation (RI) assessed the nature of ground water contamination at the site from data collected from six shallow wells within the fill area and leachate collected from eight seeps surrounding the fill area. Table 2-1 contains ranges and mean concentrations of

Figure 2-1
Combe Fill South Landfill
Ground Water Treatability Study

Alternative Process Schematics for Ground Water Treatment

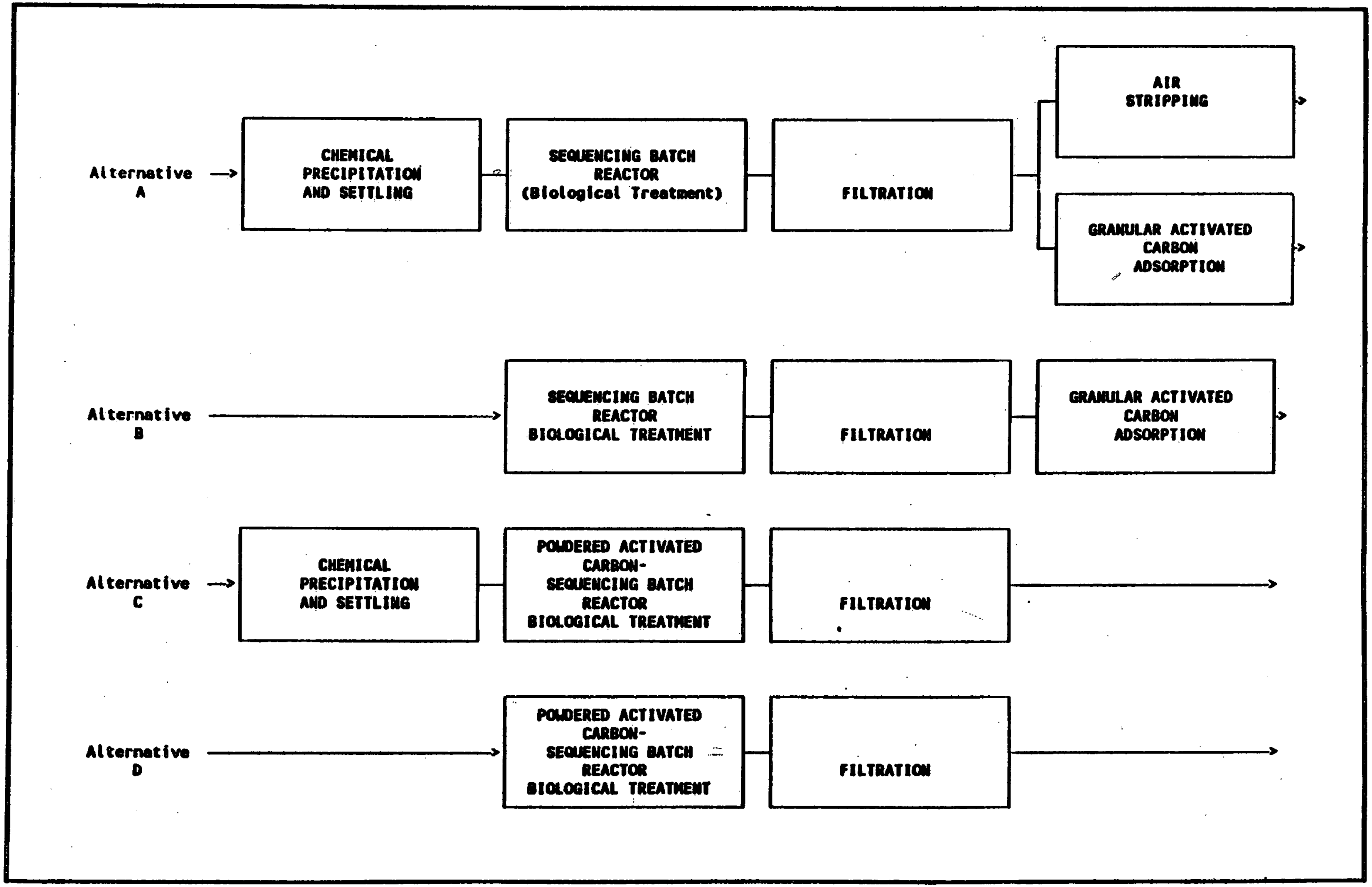


TABLE 2-1

Combe Fill South Landfill
Ground Water Treatability Study

Ground Water and Leachate Characteristics - Remedial Investigation (1986)

PARAMETER	SHALLOW GROUND WATER			LEACHATE COMPOSITE		
	MINIMUM	MAXIMUM	PREDESIGN	MINIMUM	MAXIMUM	PREDESIGN
VOLATILES (ppb)				15.0	1084.0	261.7
Benzene	0.0	80.2	26.4			
Chlorobenzene	0.0	30.3	11.6			
Chloroethane	0.0	62.0	12.0			
Chloroform	0.0	57.5	9.6			
1,1-Dichloroethane	0.0	65.2	20.2			
1,2-Dichloroethane	0.0	6.1	1.0			
1,1-Dichloroethylene	0.0	0.0	0.0			
1,2-Dichloropropane	0.0	6.0	1.0			
Ethylbenzene	0.0	7.2	1.2			
Methylene chloride	4.44	56.0	16.1			
Tetrachloroethylene	0.0	4.1	0.7			
Toluene	0.0	137.0	239.7			
Trans-1,2-dichoroethylene	0.0	8.0	1.3			
Trichloroethylene	0.0	4.0	0.7			
Vinyl Chloride	0.0	10.0	1.7			
ACID/PHENOLICS (ppb)				0.0	7.0	1.8
2,4-Dimethylphenol	0.0	0.0	0.0			
2-Nitrophenol	0.0	0.0	0.0			
Phenol	0.0	1.5	0.3			
BASE/NEUTRALS (ppb)				2.0	71.0	34.5
Bis(2-chloroethyl)ether	0.0	5.8	1.8			
Bis(2-ethylhexyl)phthalate	0.0	11.0	3.5			
1,2-Dichlorobenzene	0.0	9.77	2.8			
1,4-Dichlorobenzene	0.0	39.4	8.3			

TABLE 2- 1 (Cont'd)

Combe Fill South Landfill
Ground Water Treatability Study

Ground Water and Leachate Characteristics - Remedial Investigation (1986)

PARAMETER	SHALLOW GROUND WATER MINIMUM	SHALLOW GROUND WATER MAXIMUM	SHALLOW GROUND WATER PREDESIGN	LEACHATE COMPOSITE MINIMUM	LEACHATE COMPOSITE MAXIMUM	LEACHATE COMPOSITE PREDESIGN
BASE/NEUTRALS (ppb) Cont'd.				2.0	71.0	34.5
Di-ethyl phthalate	0.0	10.2	1.7			
Di-n-butyl phthalate	0.0	11.0	3.5			
Di-n-octyl phthalate	0.0	0.0	0.0			
Isophorone	0.0	0.0	0.0			
Naphthalene	0.0	3.2	0.5			
N-nitrosodiphenyl amine	0.0	0.0	0.0			
PESTICIDES/PCBs (ppb)				0.0	0.0	0.0
METAL (ppb)				60.0	3180.0	700.0
Beryllium	0.0	2.0	0.3			
Cadmium	0.0	3.0	0.5			
Chromium	0.0	30.0	13.3			
Copper	10.0	40.0	20.0			
Lead	9.0	28.0	16.7			
Mercury	0.0	0.2	0.1			
Nickel	0.0	30.0	11.5			
Selenium	0.0	5.0	0.8			
Silver	0.0	10.0	4.8			
Thallium	0.0	5.0	1.7			
Zinc	0.0	240.0	78.3			
MISCELLANEOUS (ppb)						
Cyanides	0.0	0.0	0.0	0.0	47.0	24.0
Phenols	0.0	270.0	45.0	0.0	418.0	212.7

organic and inorganic substances contained in the ground water as reported in the RI report. Table 2-2 contains the effluent limitations for the treatment facility as proposed by NJDEP along with the expected average influent characteristics to the proposed ground water treatment facility, as presented in the Final Conceptual Design Report [1]. These data indicate the following:

- Ground water five-day biochemical oxygen demand (BOD5) is low (approximately 100 mg/L) for a self-sustaining biological treatment system.
- Ground water total suspended solids concentration (TSS) is relatively high (about 480 mg/L).
- Relative to BOD5, ground water total organic carbon (TOC) is high (510 mg/L), suggesting the presence of biologically inert or refractory organic materials.
- Volatile organic substances are present in ground water at concentrations typically removed by biological treatment facilities (less than 10 to 100 ug/L).
- Neither pesticides nor PCBs were detected in ground water or leachate.
- Ground water heavy metal concentrations are consistently within the range compatible with biological treatment systems (less than 10 to 250 ug/L).
- Ground water concentrations of cyanides and phenols (24 and 210 ug/L, respectively) should be able to be treated with application of biological treatment systems without requiring pretreatment for these substances.

TABLE 2-2

Combe Fill South Landfill
Ground Water Treatability Study

Ground Water Influent Characteristics and Effluent Limits - Conceptual Design Report (1987)

COMPONENT	EFFLUENT LIMITATIONS	EXPECTED AVERAGE INFLUENT CHARACTERISTICS
Conventional Parameters		
Biochemical oxygen demand, 5 day (BOD_5)	8.0 mg/l monthly average 12.0 mg/l weekly average 20.0 mg/l daily maximum 90% removal efficiency	100 mg/l
Total suspended solids (TSS)	8.0 mg/l monthly average 12.0 mg/l weekly average 20.0 mg/l daily maximum 85% removal efficiency	480 mg/l
Total organic carbon (TOC)	10.0 mg/l monthly average 20.0 mg/l daily maximum	510 mg/l
pH	6.5 - 8.5	7.0
Dissolved oxygen (DO)	7.0 mg/l at any time	-
Ammonia, as nitrogen (NH_3-N)	1.0 mg/l monthly average[a]	50 mg/l
Bioassay	No measurable acute toxicity	-
	96-hr LC_{50} < 10% mortality in all samples, including 100% treatment effluent	-
Ames Test	(No numerical limit for mutagenicity)	-
Priority Pollutants		
Volatile and semivolatile organics (NJDEP "toxic" organics)	ND or <5 ppb, for any single compound, daily maximum	300 ppb
Polychlorinated biphenyls (PCBs)	ND or <0.1 ppb, daily maximum	ND
Pesticides	ND or <1.0 ppb, daily maximum	ND
Heavy metals	ND or <50 ppb, total for all metals, daily maximum	710 ppb
Total phenolics	ND or <50 ppb, daily maximum	210 ppb
Total cyanide	ND or <20 ppb, daily maximum	24 ppb

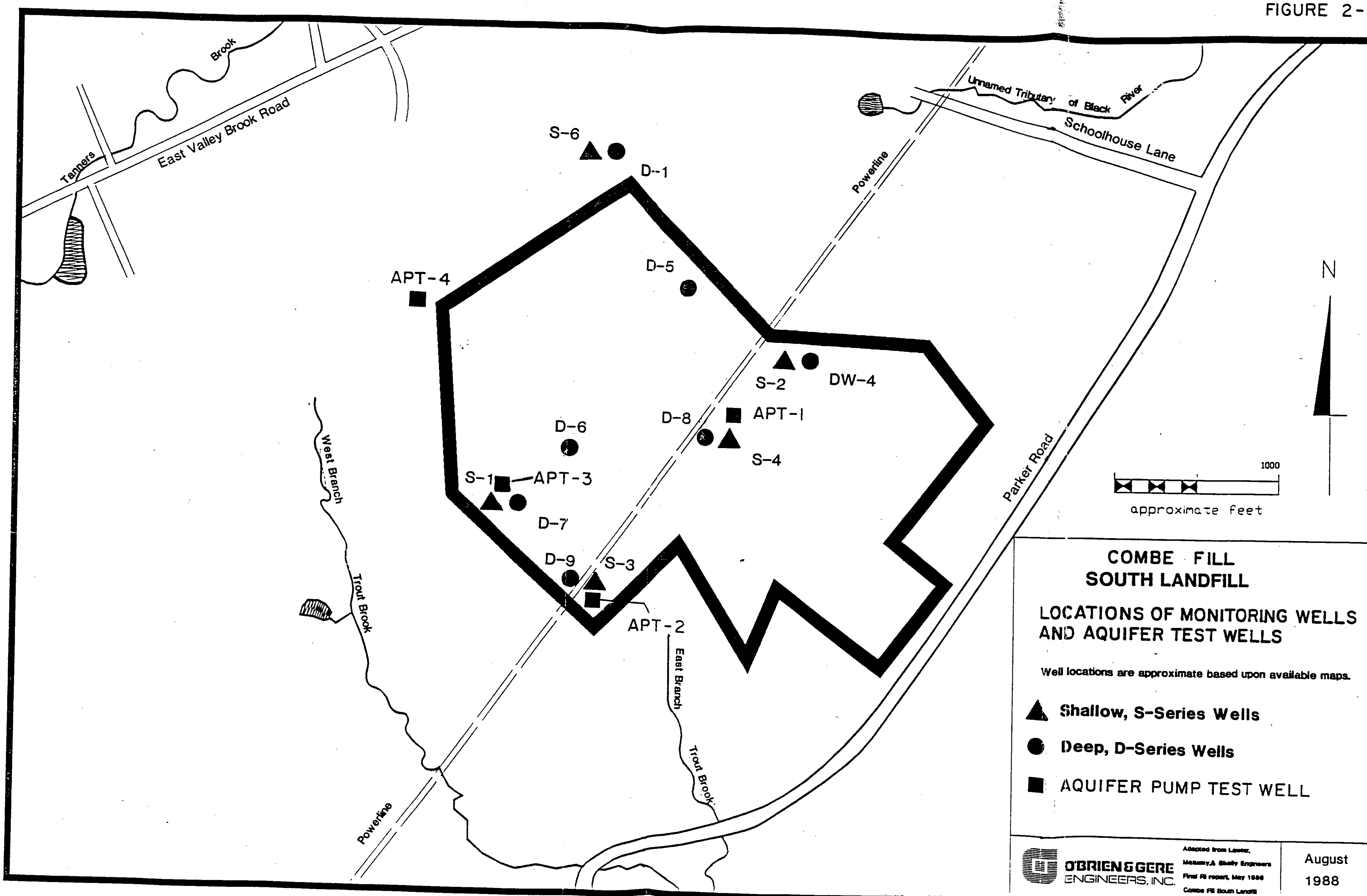
[a]Possible allowances for seasonal variations not quantified.

ND = not detectable.

Ground water characterization was conducted under the scope of the remedial design treatability testing program. Samples of ground water were collected from four aquifer pump test (APT) wells both 24 hours and 48 hours after commencement of each pump test. Figure 2-2, a plan view of the site, depicts the location of the APT wells in addition to ground water monitoring wells. The purpose of the ground water characterization effort was to determine the quality of ground water from the shallow aquifer under pumping conditions similar to those expected during future active ground water recovery and treatment.

An aliquot of each sample was filtered in the field to provide a basis for determining the distribution of metals and Total Organic Carbon (TOC) between the particulate and aqueous phase of the ground water. Additionally, the eight APT samples were analyzed for total phenolics, volatile organics (Environmental Protection Agency (EPA) Methods 601 and 602), total metals (beryllium, cadmium, calcium, copper, chromium, iron, lead, magnesium, nickel, selenium, silver, thallium, and zinc), five day biochemical oxygen demand (BOD5), chemical oxygen demand (COD), TOC, field pH, acidity, alkalinity, field conductivity, Total Kjeldahl Nitrogen (TKN), ammonia, nitrate-nitrite, total phosphorus, total suspended solids (TSS), total dissolved solids (TDS), sulfate, field dissolved oxygen, pesticides/PCBs (EPA Method 608), cyanide, and total and fecal coliform. All analyses were conducted by U.S. Testing of Hoboken, New Jersey, an NJDEP approved and Resource Conservation & Recovery Act (RCRA) permitted laboratory.

FIGURE 2-2



Tanners Brook
East Valley Brook Road
Unnamed Tributary of Black River
Schoolhouse Lane
Powerline
S-6
D-1
D-5
APT-4
S-2
DW-4
APT-1
D-8
S-4
D-6
S-1
APT-3
D-7
D-9
S-3
APT-2
West Branch
Trout Brook
East Branch
Trout Brook
Parker Road
Powerline
N
1000
approximate feet
COMBE FILL
SOUTH LANDFILL
LOCATIONS OF MONITORING WELLS
AND AQUIFER TEST WELLS
Well locations are approximate based upon available maps.
Shallow, S-Series Wells
Deep, D-Series Wells
AQUIFER PUMP TEST WELL
O'BRIEN & GERE ENGINEERS, INC.
August
1988

All results of the supplemental sampling and analysis are contained in Table 2-3. Table 2-4 contains a summary of analytical results obtained from testing of pump test water samples collected at hour 24 from APT wells 2 and 3 along with a summary of ground water quality data obtained from monitoring wells S-1 and S-3 during the RI and the Interim Environmental Monitoring Program (IEMP). Monitoring wells S-1 and S-3 are located near APT wells 2 and 3. APT wells 2 and 3 contained the most significant chemical constituents present in ground water monitoring wells during the RI.

Ground water samples collected from APT wells 2 and 3 contained lower concentrations of volatile organics than those reported for adjacent ground water monitoring wells S-1 and S-3 during the RI and IEMP. For example, 1,1 dichloroethane, found at approximately 65 ug/L and 51 ug/L respectively in monitoring well S-1 and S-2 during the RI, was not found in detectable quantities in either APT well 2 or 3. A number of factors could explain the observed differences between volatile organic data obtained during the RI and the APT, including: a depletion of the source of volatile organics, differences between APT well and monitoring well construction (i.e., well segments screened), and differences in ground water recharge and flow brought about by differences in rainfall received at the site prior to sampling.

Metals data generated from APT well samples were similar to those collected from the monitoring wells during the RI. Heavy metals of concern include nickel and zinc which were present in ground water. Samples from APT wells at concentrations ranging from less than 12.4 ug/L to 201 ug/L and from 4.8 ug/L to 364 ug/L, respectively.

TABLE 2- 3

Combe Fill South Landfill
Ground Water Treatability Study

Analytical Results from 24 and 48 Hour Aquifer Pump Tests

		CFS PT-1		CFS PT-2		CFS PT-3		CFS PT-4	
	DETECT LIMIT	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr
VOLATILE ORGANICS (ppb)									
chloroethane	10	U	U	13	12	U	9J	U	U
methylene chloride	5	U	U	100	6J	1J	U	U	U
acetone	10	U	U	90	94	13	38	U	U
trans-1,2-dichloroethene	5	U	U	4J	4J	U	U	U	U
chloroform	5	5	9	U	U	U	U	47	54
2-butanone	10	U	U	230	230	U	U	U	U
1,2-dichloropropane	5	U	U	3J	3J	U	U	U	U
benzene	5	5	10	16	15	U	U	U	U
4-methyl-2-pentanone	10	U	U	33	34	U	1J	U	U
2-hexanone	10	U	U	8J	7	U	4J	U	U
toluene	5	U	U	190	150	U	U	U	U
chlorobenzene	5	22	33	52	47	U	U	U	U
ethylbenzene	5	U	U	7J	6	U	U	U	U
total xylenes	5	U	U	13	13	U	4J	U	U
PESTICIDES AND PCBs (ppb)		U	U	U	U	U	U	U	U
METALS (ppb)									
aluminum		173B	75.4B			1940	958	44U	44U
antimony		33U	33U	124.1	129.5	33U	33U	88.4	125
arsenic		4.8U	4.8U	93.8	106	4.8U	4.8U	4.8U	4.8U
barium		140B	191B			63B	634	12.2B	75.8B
beryllium		1.5U	1.5U	4.3B	2.9B	1.5U	1.5U	1.5U	4.3B
cadmium		3.5U	3.5U	8.9	9.4	3.5U	3.5U	6.6	9.2
calcium		106000	153000	148000	153000	148000	116000	5920	6120
chromium		5.9B	12.8	7.1B	6.4B	10.8	9.7B	5.2U	5.2U
cobalt		21.4B	29.6B			36.9B	31.6B	3.4B	4.2B
copper		9.3U	9.3U	9.3U	79.7	9.3U	9.3U	9.3U	9.3U
iron		6350	8840	57100	54100	60100	70100	678	104
lead		5U	5U	5U	37.2	5U	5U	5U	5U
magnesium		37100	56200	69600	73100	75200	73800	2540B	2650B
manganese		13300	19200			6820	6830	28.2	25.3
mercury		.2U	.2U			.2U	.2U	.2U	.2U
nickel		12.4U	12.4U	12.4U	201	12.4U	12.4U	12.4U	12.4U
potassium		4750B	6670			17200	20900	947B	1020B
selenium		5U	5U	35U	35	5U	5U	5U	5U
silver		6.7U	6.7U	6.7U	6.7U	6.7U	6.7U	6.7U	6.7U
sodium		234000	341000			23600	1130000	6080	6140
thallium		9.1U	9.1U	9.1U	9.1U	9.1U	9.1U	9.1U	9.1U
vanadium		4.5U	4.5U			4.5U	4.5U	4.5U	4.5U
zinc		93.1	108	91.3	276.7	44.8	51.3	23.0	12.3B
cyanide		10U	10U	10U	10U	10.0U	10.0U	10U	10U
phenols		5U	5U	5U	5U	5.0U	5.0U	5U	5U

TABLE 2-3 (Cont'd)

Combe Fill South Landfill
Ground Water Treatability Study

Analytical Results from 24 and 48 Hour Aquifer Pump Tests

	CFS PT-1		CFS PT-2		CFS PT-3		CFS PT-4	
	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr
FILTERED METALS (ppb)								
aluminum	1838	729			347	44U	44U	44U
antimony	33U	33U	121.3	131.1	33U	33U	107	112
arsenic	4.8U	4.8U	85.1	88.7	4.8U	4.8U	4.8U	4.8U
barium	225	220			574	7.3B	8.9B	8.7B
beryllium	1.5U	1.5U	2.4B	4.3B	1.5U	1.5U	3.3B	4.3B
cadmium	3.5U	3.5U	10.1	9.0	3.5U	3.5U	7	9.2
calcium	169000	162000	149000	156000	157000	20408	5920	5960
chromium	30.1	13.8	10.4	11.3	5.2U	5.2U	5.2U	5.2U
cobalt	30.4B	28.5B			32.1B	2.8U	2.8B	3.5B
copper	9.3U	9.3U	9.3U	9.3U	9.4B	9.3U	9.3U	9.3U
iron	9490	11900	21600	26900	53400	226	4.8U	12.5B
lead	5U	5U	5U	5U	5U	5U	5U	5U
magnesium	64300	60800	70900	74100	80300	559B	2530B	2590B
manganese	21000	19600			7010	18.5	24.5	21.6
mercury	.2U	.2U			.2U	.2U	.2U	.2U
nickel	12.4U	12.4U	12.4U	12.4U	12.4U	12.4U	12.4U	12.4U
potassium	7490	7080			17700	17800	903B	980B
selenium	5U	5U	35U	35U	5U	5U	5U	5U
silver	6.7U	6.7U	6.7U	6.7U	6.7U	6.7U	6.7U	6.7U
sodium	377000	357000			259000	1600000	6040	6050
thallium	9.1U	9.1U	9.1U	9.1U	9.1U	9.1U	9.1U	9.1U
vanadium	4.5U	4.5U			4.5U	4.5U	4.5U	4.5U
zinc	124	135	104.1	363.9	61.7	5.18	4.8B	17.3B
cyanide	10U	10U	10U	10U			10U	10U
phenols			5U	5U			5U	5U
pH	6.59	6.77	6.44	6.23	6.59	6.95		
TSS (mg/l)	26	24	3	12	60	27	1.0	2.0
TDS (mg/l)	1507	1469	1364	1416	1314	1326	121	64
specific conductance (umhos/cm)	1970	2100	1810	1936	1950	2100		
chloride (mg/l)	564	580						
nitrite (mg/l)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
nitrate (mg/l)	5.6	5.6	5.7	1.8	2.7	3.0	0.45	0.47
COD (mg/l)	141.4	141.4	116.7	144.4	126.6	135.3	11.8	7.9
TKN (mg/l)	3.99	2.24	<0.28	<0.28	16.52	2.24	<0.14	<0.14
ammonia (mg/l)	<0.1	<0.1	<0.1	<0.1	8.35	1.43	<0.1	<0.1
sulfate (mg/l)	2.4	3.7	11.8	16.6	1.8	1.6	4.4	3.8
alkalinity (mg/l)	440	448	485	523	595	596	22.0	28.0
acidity (mg/l)	135	46	329	464	223	51	1.0	1.0
TOC (mg/l)	64.6	68	145.8	149	70.7	58.5	12.3	10.5
phosphorous (mg/l)	1.48	<0.2	0.315	<0.2	1.30	0.59	0.82	0.90
BOD (mg/l)	<10	<10	68	63	<10	15	<10	<10
total coliform bacteria (mpn/100ml)	<2	<2	<2	<2	13	<2	<2	<2

U - Undetected
B - Also Detected in Blank
J - Detected, but Below Method Detection Limit

TABLE 2-4

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

GROUND WATER CHARACTERISTICS (1986, 1988, 1989)

			RI		IEMP		Aquifer Pump Test		Treatability Study					
COMPOUND	Unit	Detection Limit (YORK)	S-1(PT-3) 5/86 (LMSE)	S-3(PT-2) 5/86 (LMSE)	S-1(PT-3) 12/88	S-3(PT-2) 12/88	PT-2* 12/1/88 (US TESTING)	PT-3* 12/1/88 (US TESTING)	COMP. PT-2/PT-3** 3/27/89 (YORK)	COMP. PT-2/PT-3** 4/17/89 (YORK)	COMP. PT-2/PT-3** 5/05/89 (YORK)	COMP. PT-2/PT-3** 5/19/89 (YORK)	COMP. PT-2/PT-3** 6/02/89 (YORK)	COMP. PT-2/PT-3** 6/15/89 (YORK)
Chloroethane	ug/l	10	U	10J	U	U	13	U	U	U	U	U	U	U
Methylene Chloride	"	5	56	18.4	3J	U	100	1J	6	5	4JB	3J	U	U
Acetone	"	10	-	-	240	U	90	13	-	U	U	U	U	U
Carbon Disulfide	"	5	-	-	3J	U	-	-	-	-	-	U	U	U
Vinyl Acetate	"	10	-	-	11	U	-	-	-	-	-	U	U	U
t-1,2-Dichloroethene	"	5	U	8.02	-	-	4J	U	-	U	U	U	U	U
1,1-Dichloroethane	"	5	65.2	51.4	-	-	U	U	U	U	U	U	U	U
1,2-Dichloroethane	"	5	U	U	-	-	U	U	U	U	41	22	22	U
Trichloroethylene	"	5	U	4.04	-	-	U	U	U	U	U	U	U	U
Tetrachloroethylene	"	5	U	4.1J	-	-	U	U	U	U	U	U	U	U
2-Butanone	"	10	-	-	-	-	230	U	-	U	U	U	U	U
1,2-Dichloropropane	"	5	U	6J	-	-	3J	U	U	U	U	U	U	U
Benzene	"	5	64.7	80.2	44	U	16	U	10	10	7	6	4J	3J
4-Methyl-2-Pentanone	"	10	-	-	32	U	33	U	-	U	U	U	U	U
2-Hexanone	"	10	-	-	6J	U	8J	U	-	U	U	U	U	U
Toluene	"	5	1370	68.2	130	U	190	U	42	42	57	42	12	28
Chlorobenzene	"	5	U	21.1	27	U	52	U	25	25	17	15	18	14
Ethylbenzene	"	5	U	7.2J	12	U	7J	U	5	5	11	27	3J	2J
Total Xylenes	"	5	-	-	33	U	13X	U	-	-	-	U	U	U
Vinyl Chloride	"	10	U	10J	-	-	U	U	U	U	U	U	U	U
pH	S.U.	-	-	-	6.4	6.1	6.4	6.5	6.2	-	-	-	-	-
TSS	mg/l	-	-	-	217	99	3	60	330	21	18	18	19	47
TDS	"	-	-	-	1454	2396	1364	1314	-	-	-	-	-	-
TOC	"	-	-	-	-	-	145.8	70.7	58	61	52	11	57	181
COD	"	-	-	-	113.2	863.8	116.6	126.6	-	-	-	-	-	-
BOD5	"	-	-	-	64	530	68	<10	61	58	55	9	53	45
Ammonia	"	-	-	-	<0.1	<0.1	<0.1	8.35	8.8	8.8	8.18	8.9	12.5	11.8
TKN	"	-	-	-	2.17	<0.28	<0.28	16.52	-	-	-	-	-	-
P	"	-	-	-	0.96	1.67	0.315	1.3	-	-	-	-	-	-

* Samples collected during pump test (24 hr).
** Samples collected for treatability studies & composited at equal volume.
U Undetected
J Detected but less than method detection limit
B Also detected in blank

BOD5 values for ground water samples from APT wells were lower than values reported during the IEMP (approximately 58 mg/L compared to greater than 100 mg/L).

Landfill capping is expected to severely limit leachate generation. Existing ground water in the vicinity of the fill is affected by leachate. Future ground water quality should improve over time due to reduced leachate generation.

The landfill gas condensate (LGC) volume anticipated as part of the treatment plant influent has been estimated by an evaluation of the volume and the timing associated with the placement of solid waste at the landfill and the technical literature available on the subject. Landfill gas condensate is a two-phase liquid containing an aqueous and an organic phase of variable proportion depending on the site.

Condensate quality in terms of BOD5, TOC, and COD varies considerably among sites and, in general, is similar to landfill leachate with a BOD5 ranging from 1,000 to 30,000 mg/L, and COD and TOC concentrations present as a multiple of BOD5 concentrations. This multiple typically ranges from 2 to 10, depending on the composition and age of landfill contents.

Table 2-5 indicates condensate quality which would be expected based on similar sites. Table 2-6 contains actual landfill gas condensate characterization data for the Combe Fill South Landfill. Condensate samples were collected on September 6 and 7, 1989. These samples were characterized by York Laboratories of Monroe, Connecticut for BOD5, COD, TOC, phosphorus, ammonia-nitrogen, TKN, nitrate-nitrogen, and volatile organics. The results of sampling and

TABLE 2-5
COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

EXPECTED LANDFILL GAS CONDENSATE CHARACTERISTICS

PARAMETER	UNITS	VALUE
Condensate Flow	gpd	5,000
BOD5	mg/l	10,000
COD	mg/l	20,000
TOC	mg/l	10,000
TSS	mg/l	<25
Total Metals	mg/l	<0.25
VOC	mg/l	10
Total Phenolics	mg/l	10

TABLE 2-6

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

ACTUAL LANDFILL GAS CONDENSATE CHARACTERISTICS
SAMPLES COLLECTED 9/6-7/89

CONVENTIONAL PARAMETERS

PARAMETER	CONCENTRATION (mg/l)
Ammonia-Nitrogen	23.8
Biochemical Oxygen Demand (5 day)	12
Chemical Oxygen Demand	98.8
Nitrate-Nitrogen	<0.10
Phenols	0.092
Phosphorus, total	<0.15
Total Kjeldahl Nitrogen	24.2
Total Organic Carbon	24.8

VOLATILE ORGANICS

PARAMETER	METHOD DETECTION LIMIT (ug/l)	CONCENTRATION (ug/l)
Chloromethane	10	U
Bromomethane	10	U
Vinyl Chloride	10	U
Chloroethane	10	U
Methylene Chloride	5	10B
Acetone	10	U
Carbon Disulfide	5	U
1,1-Dichloroethene	5	U
1,1-Dichloroethane	5	U
1,2-Dichloroethene (total)	5	U
Chloroform	5	U
1,2-Dichloroethane	5	U
2-Butanone	5	U
1,1,1-Trichloroethane	10	U
Carbon Tetrachloride	5	U
Vinyl Acetate	5	U
Bromodichloromethane	10	U
1,2-Dichloropropane	5	U
c-1,3-Dichloropropene	5	U
Trichloroethene	5	U
Dibromochloromethane	5	U
1,1,2-Trichloroethane	5	U
Benzene	5	U
t-1,3-Dichloropropene	5	U
Bromoform	5	U
4-Methyl-2-pentanone	10	U
2-Hexanone	10	U
Tetrachloroethene	5	U
1,1,2,2-Tetrachloroethane	5	U
Toluene	5	21
Chlorobenzene	5	3J
Ethylbenzene	5	16
Styrene	5	U
Xylene (total)	5	33

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

characterizing one sample of Combe Fill South Landfill LGC suggest that a low-strength LGC might be expected.

Calculations performed utilizing the thermodynamic properties of saturated air indicate that for an flow rate of 2,000 cubic feet per minute (CFM) at an temperature of 100° Fahrenheit, approximately 1,000 gallons per day of water would be condensed. If the temperature rises to 150°F, approximately 3,600 gallons per day of water would be generated. If the flow rate increases to 3,000 CFM, approximately 1,500 gallons per day of water would be condensed at a temperature of 100° F and approximately 5,400 gallons per day of water would be generated at a temperature of 150°F.

Although the above temperatures are greater than the temperatures measured at two wells installed in the Combe Fill South Landfill, information presented in Methane Generation and Recovery from Landfills by Emcon Associates [2], indicate that temperatures in landfills 15 meters (49 feet) in thickness have been observed as high as 70° C (158° F). In a paper titled "Landfill Gas Condensate and Its Disposal" by Ronald J. Lofy [3] landfill gas temperatures from 70° F to 150° F are reported. Therefore, it may be possible to encounter landfill gas temperatures as high as 150° F at Combe Fill South Landfill.

In a paper titled "Municipal Landfill Gas Condensate" prepared in 1987 by SCS Engineers, Inc. [4] for the Environmental Protection Agency, actual condensate generation rates from operating landfill gas systems are reported as ranging from 44 to 162 liters per 1,000 cubic meters of unprocessed landfill gas which converts to 329 to 1,211 gallons per million cubic feet of gas extracted. This, in turn, converts to quantities of condensate ranging from approximately 950 to 3,500 gallons per day for a gas flow rate of 2,000 CFM and from 1,425 to 5,250 gallons per day for a flow rate or 3,000 CFM. Lofy recommends designing for a flow rate of 1,400 gallons per million cubic feet of gas extracted which converts to quantities of 4,000 gallons per day for an extraction rate of 2,000 CFM and 6,000 gallons per day for an extraction rate of 3,000 CFM.

When the Ground Water Treatment Facility Preliminary Design Report was prepared in September of 1989, the design gas extraction rate was 3,000 CFM. Based on input from NJDEP, the design rate has been modified to 2,000 CFM with the extraction system having the ability to handle up to 3,000 CFM. Given the reported literature values for landfill gas and condensate generation rates, a condensate design flow rate of 5,000 gallons per day has been selected in order to insure that adequate treatment capacity will be available.

2.04 Preliminary Evaluation of Alternatives

Ground water and leachate data generated during the RI (Tables 2-1 and 2-2) along with the proposed effluent discharge limitations (Table 2-2) indicate that treatment must provide for removal of: BOD5, TSS, TOC, ammonia-nitrogen, volatile organics, heavy metals, and total phenolics. The Final Conceptual Design Report [1] suggested the following train of unit processes for the treatment of ground water collected from the Combe Fill South Landfill: hydraulic equalization, chemical precipitation of heavy metals, biological treatment of organics, dual media filtration, and activated carbon adsorption polishing.

Recent studies [5,6] demonstrated the cost effectiveness of using powdered activated carbon (PAC) assisted biological treatment of contaminated ground water and leachate. This technology combines the essential elements of three of the recommended unit operations for treating ground water at the site: biological treatment of organics, filtration of solids, and carbon adsorption polishing of organics. Another recent study [7] documented the effectiveness of combining the PAC biological treatment concept with sequencing batch reactors (SBR). Such a system provided excellent effluent quality, operational flexibility, and low operator attention making it a favorable option for treatment of ground water. Therefore, bench scale testing for biological treatment of ground water involved SBRs combined with PAC enhanced biological treatment.

2.05 Treatability Testing Approach

All treatability testing was performed in the pilot study facilities located in O'Brien & Gere's Syracuse office. Analytical testing was conducted by York Laboratories of Monroe, Connecticut. All analytical testing performed in association with the treatability studies conformed to the contract required detection limits. Table 2-7 lists the method detection limits.

Ground water samples were obtained in equal volume portions from APT wells 2 and 3 once every two weeks. These samples were composited and transported to O'Brien & Gere's Syracuse office for storage at 4 degrees Celsius prior to treatability testing. Ground water from APT wells 2 and 3 was selected for treatability testing based on the presence of these wells in the area of the site which has shown the highest levels of organic and inorganic substances in the ground water.

TABLE 2-7

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY
METHOD DETECTION LIMITS

VOLATILE ORGANIC COMPOUNDS

Compound	Method Detection Limits with no Dilution (ppb)
Chloromethane	10
Bromomethane	10
Vinyl chloride	10
Chloroethane	10
Methylene Chloride	5
Trichlorofluoromethane	10
acrolein	100
acrylonitrile	35
1,1-dichloroethene	5
1,1-dichloroethene (total)	5
Chloroform	5
1,2,dichloroethane	5
Bromodichloromethane	5
1,2-dichloropropane	5
Cis-1,3-dichloropropene	5
2-chloroethylvinyl ether	5
Trichloroethylene	5
Dibromochloromethane	5
1,1,2-trichlorethane	5
Benzene	5
Trans-1,3-dichloropropene	5
Bromoform	5
Tetrachloroethylene	5
1,1,2-2-tetrachloroethane	5
Toluene	5
Chlorobenzene	5
Ethyl benzene	5

TABLE 2-7

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY
METHOD DETECTION LIMITS

SEMI-VOLATILE ORGANICS

Compound	Method Detection Limits with no Dilution (ppb)
N-nitrosodimethyl amine	10
bis (2-chloroethyl) ether	10
1,3-dichlorobenzene	10
1,4-dichlorobenzene	10
1,2-dichlorobenzene	10
bis (2-chloroisopropyl) ether	10
hexachloroethane	10
N-nitroso-di-n-propylamine	10
nitrobenzene	10
isophorone	10
bis (2-chloroethoxy) methane	10
1,2,4-trichlorobenzene	10
naphthalene	10
hexachlorobutadiene	10
hexachlorocyclopentadiene	10
2-chloronaphthalene	10
dimethyl phthalate	10
acenaphthylene	10
2,6-dinitrotoluene	10
acenaphthene	10
2,4-dinitrotoluene	10
diethyl phthalate	10
fluorene	10
4-chlorophyenl-phenyl ether	10
4-bromophenyl-phenyl ether	10
N-nitrosodiphenylamine(1)	10
hexachlorobenzene	10
phenanthrene	10
anthracene	10
di-n-butyl phthalate	10
fluoranthene	10
benzidine	80
pyrene	10
butyl benzyl phthalate	10
3,3-dichlorobenzidine	20
chrysene	10
benzo(a)anthracene	10
bis(2-ethyl hexyl) phthalate	10
di-n-octyl phthalate	10

TABLE 2-7

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY
METHOD DETECTION LIMITS

SEMI-VOLATILE ORGANICS
(Continued)

Compound	Method Detection Limits with no Dilution (ppb)
benzo(b)fluoranthene	10
benzo(k)fluoranthene	10
benzo(a)pyarene	10
benzo(g,h,i)perylene	10
dibenzo(a,h)anthracene	10
Indeno(1,2,3,c,d)pyrene	10
1,2-diphenylhydrazine(2)	10
phenol	10
2-chlorophenol	10
2-nitrophenol	10
2,4-dimethylphenol	10
2,4-dichlorophenol	10
2,4-dichlorophenol	10
4-chloro-3-methyl phenol	10
2,4,6-trichlorophenol	10
2,4-dinitrophenol	50
4-nitrophenol	50
2-methyl-4,6-dinitrophenol	50
pentachlorophenol	50

TABLE 2-7

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY
METHOD DETECTION LIMITS

PESTICIDES/PCBs

Compound	Method Detection Limits with no Dilution (ppb)
alpha BHC	0.01
beta BHC	0.01
gamma BHC	0.01
delta BHC	0.01
Heptachlor	0.01
Aldrin	0.01
4,4' DDE	0.01
Dieldrin	0.01
4,4' DDD	0.05
Endrin Aldehyde	0.05
4,4' DDT	0.05
Chlorodane	0.10
Endosulfan I	0.01
Endosulfan II	0.05
Endosulfan Sulfate	0.05
Endrin	0.05
Heptachlor Epoxide	0.01
Toxaphene	1.0
PCB - 1016	0.20
PCB - 1221	0.20
PCB - 1232	0.20
PCB - 1242	0.20
PCB - 1248	0.20
PCB - 1254	0.20
PCB - 1260	0.20

TABLE 2-7

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY
METHOD DETECTION LIMITS

METALS

Compound	Method Detection Limits with no Dilution (ppb)
Antimony	60.0
Arsenic	10
Beryllium	5.0
Cadmium	10
Chromium	10
Copper	25
Iron	100
Lead	5
Mercury	0.20
Nickel	40.0
Selenium	5.0
Silver	10
Thallium	10
Zinc	20

Testing was completed for most unit operations contained on Figure 2-1. Polishing filtration and air stripping tests were not performed on the biological treatment systems' effluents. The TSS of the biological treatment systems' effluents were sufficiently low (generally less than 8 mg/l) to render filtration polishing unnecessary prior to granular activated carbon (GAC) testing.

Volatile organic concentrations in the effluents from the bench scale SBRs were non-detectable or at or below the detection limit of 5 ug/l for six out of the seven days sampled (Section 2.07). Methylene chloride was found in effluents from two SBRs at 7 and 8 ug/l on May 10, 1989, but it was also found in the blank. These observations indicate that VOCs were effectively removed from the ground water by the SBRs. Therefore, air stripping testing was not performed.

Landfill gas condensate (LGC) was recognized as a component of the future wastestream after the initiation of the treatability studies. However, the volume of LGC produced from a small scale gas withdrawal test was insufficient to conduct reasonably scaled biological treatability studies (one liter of feed per day or greater).

2.06 Metals Removal

Since effluent requirements for metals are generally less than the solubility limits for metal hydroxides, co-precipitation with iron was evaluated for removal of heavy metals. Jar tests were conducted to evaluate the effectiveness of pH adjustment and ferric sulfate addition for heavy metals removal. Precipitation tests were conducted over the pH range of minimum heavy metals solubility (8.5 - 10.0). Three pH levels (8.5, 9.5, and 10 S.U.) and four ferric sulfate dosages (0, 50, 100, and 200 mg/L) were used in the study. The analytical program involved testing for influent and effluent TSS, pH, and selected heavy metals.

Heavy metals precipitation jar tests were conducted using a standard six-paddle jar testing device. A 1000 milliliter (ml) sample of ground water was placed in a 1500 ml beaker and rapidly mixed (100 rpm). Ferric sulfate was added to the ground water sample and the pH was adjusted using 1N sodium hydroxide. At a ferric sulfate dose of 100 mg/l, alkalification of ground water to pH 8.5, 9.5, and 10.0 S.U. required 14.4, 24.0, and 29.0 ml., respectively, of 1N sodium hydroxide solution. The contents of the beakers were rapidly mixed (100 rpm) for 30 seconds and then flocculated (30 rpm) for 15 minutes. The resulting metal hydroxide and iron floc was allowed to settle for approximately one hour and the resulting supernatants were analyzed for TSS, pH, and selected heavy metals.

The chemical addition regime producing the best metals removal efficiency was further tested to evaluate the corresponding sludge generation rates and sludge settling characteristics. A settling column test was conducted by employing a five foot long, eight inch diameter settling column and adding 0.5 mg/L of anionic polyelectrolyte (M835A) to enhance sludge settling. The interface depth (ft) versus settling time (min) was recorded over a 2 hour period and plotted to determine sludge settling rates. The volume of settled sludge and corresponding solids concentration was recorded along with supernatant pH and TSS.

Table 2-8 presents the results of ground water heavy metals co-precipitation with ferric sulfate. All of the dosage schemes reduced ground water chromium, copper, and lead from pretreatment values of 25.8, 45.4, and 5.5 ug/L, respectively, to less than the corresponding

TABLE 2-8

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE PRECIPITATION TESTING RESULTS

SAMPLE	Fe3+ mg/l	pH S.U.	Sb ug/l	As ug/l	Be ug/l	Cd ug/l	Cr ug/l	Cu ug/l	Fe ug/l	Pb ug/l	Hg ug/l	Ni ug/l	Se ug/l	Ag ug/l	Tl ug/l	Zn ug/l	TSS mg/l
COMP.GW	-	-	-	-	-	-	25.8	45.4	87,800	5.5	-	<40	-	-	-	166	330
CFS1-1	0	8.5	-	-	-	-	<10	<25	224	<5	-	<40	-	-	-	23.8	<1
CFS1-2	50	8.5	-	-	-	-	<10	<25	190	<5	-	<40	-	-	-	<20	2
CFS1-3	100	8.5	-	-	-	-	<10	<25	897	<5	-	<40	-	-	-	<20	8
CFS1-4	200	8.5	<60	<10	<5	<10	<10	<25	477	<5	<0.2	<40	<5	<10	<10	<20	<1
CFS1-5	0	9.5	<60	<10	<5	<10	<10	<25	199	<5	<0.2	<40	<5	<10	<10	25.6	<1
CFS1-6	50	9.5	-	-	-	-	<10	<25	105	<5	-	<40	-	-	-	36.1	16
CFS1-7	100	9.5	-	-	-	-	<10	<25	237	<5	-	<40	-	-	-	22	14
CFS1-8	200	9.5	<60	<10	<5	<10	<10	<25	238	<5	<0.2	<40	<5	<10	<10	<20	3
CFS1-9	0	10	-	-	-	-	<10	<25	110	<5	<0.2	<40	-	-	-	<20	14
CFS1-10	50	10	-	-	-	-	<10	<25	152	<5	-	<40	-	-	-	41.3	12
CFS1-11	100	10	-	-	-	-	<10	<25	143	<5	-	<40	-	-	-	<20	12
CFS1-12	200	10	<60	<10	<5	<10	<10	<25	173	<5	<0.2	<40	<5	<10	<10	<20	2

method detection limits (10, 25, and 5 ug/L, respectively). Zinc data generated from the co-precipitation study indicates that a ferric sulfate dose of at least 50 mg/L as iron is required to effectively eliminate zinc from the ground water. Zinc precipitation was relatively insensitive to pH over the range employed for this study (8.5 - 10 S.U.) as indicated by the insignificant difference between dosage schemes employing the same ferric sulfate dose at different pH values. The TSS of the ground water was reduced from a pretreatment concentration of 330 mg/L to less than 16 mg/L for all dosage schemes, with greater reduction occurring at pH 8.5.

Heavy metals characterization of ground water prior to precipitation testing involved only those metals considered an issue at the CFSL, based on results presented in the Remedial Investigation Report. Laboratory characterization of treated ground water indicates that other heavy metals, if present in the ground water, were effectively removed by precipitation at pH 8.5.

Based upon these results, a ferric sulfate dose of 100 mg/L and a pH of 8.5 was chosen as the optimal heavy metals pretreatment for Combe Fill South Landfill ground water. A ferric sulfate dose of 100 mg/l was selected to remove heavy metals to concentrations below effluent discharge limitations. During the precipitation jar tests, chromium, copper, and lead were effectively removed from composite ground water at all pHs and ferric sulfate doses employed. Zinc was not consistently removed from solution at the 50 mg/l ferric sulfate dose at pH values of 9.5 or 10.5. Therefore, as a conservative approach, it was decided to dose with 100 mg/l ferric sulfate at a pH of 8.5 in order to consistently provide optimal zinc removals. This pretreatment method was used to prepare feed to the bench-scale SBR requiring removal of heavy metals (Alternatives A and C, Figure 2-1). Table 2-9 contains the pretreatment conditions used to prepare the pretreatment feeds for the SBRs.

Figure 2-3 presents the results of the settling column study performed on sludge generated from heavy metals pretreatment of site ground water. Approximately 2000 ml of iron and metal hydroxide sludge produced at pH 8.5 and ferric sulfate dose of 100 mg/l and conditioned with 0.25 mg/l anionic polymer (American Cyanamid 835A) was added to a 2000 ml graduated cylinder. The sludge interface depth, chosen as the distance from the air-water interface to the sludge interface, was monitored with time. Figure 2-3 depicts the depth of the settling sludge interface as a function of settling time in minutes. The initial settling velocity, as calculated from the slope of the first linear section of the curve, is approximately 0.5 feet per minute. This initial settling velocity was used to size the inclined plate clarifier proposed for removal of sludge generated from ground water pretreatment.

2.07 Biological Treatment

The efficiency and efficacy of biological treatment of the ground water was evaluated using sequencing batch reactors. Three two liter volume SBRs were operated in a fill and draw mode for 15 weeks according to the cycle time composition schedule appearing in Table 2-10. This operation produced a hydraulic retention time of 24 hours. The solids retention time was maintained at greater than 20 days.

The three SBRs represented three different treatment scenarios corresponding to treatment configurations A, C and D appearing in

TABLE 2-9

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BIWEEKLY GROUND WATER SAMPLE PRE-TREATMENT CONDITIONS

Volume	:	35 liters
Fe2(SO4)3	:	100 mg/l as Fe
Initial pH range	:	6.0 - 6.5 S.U.
Average 50% NaOH added	:	19.3 ml
Treated pH	:	8.5 S.U.
Polymer (M835A)	:	0.25 mg/l
TSS before treated	:	434 mg/l
TSS after treated	:	569 mg/l
Settling time	:	2 hours
Supernatant TSS	:	8 mg/l
Sludge Volume	:	1.8 liters (5% v/v)
Sludge percent solids	:	1.54%

Figure 2-3

'Combe Fill South Landfill
Ground Water Treatability Study

Settling Column Test Results For Metals Pretreatment Sludge

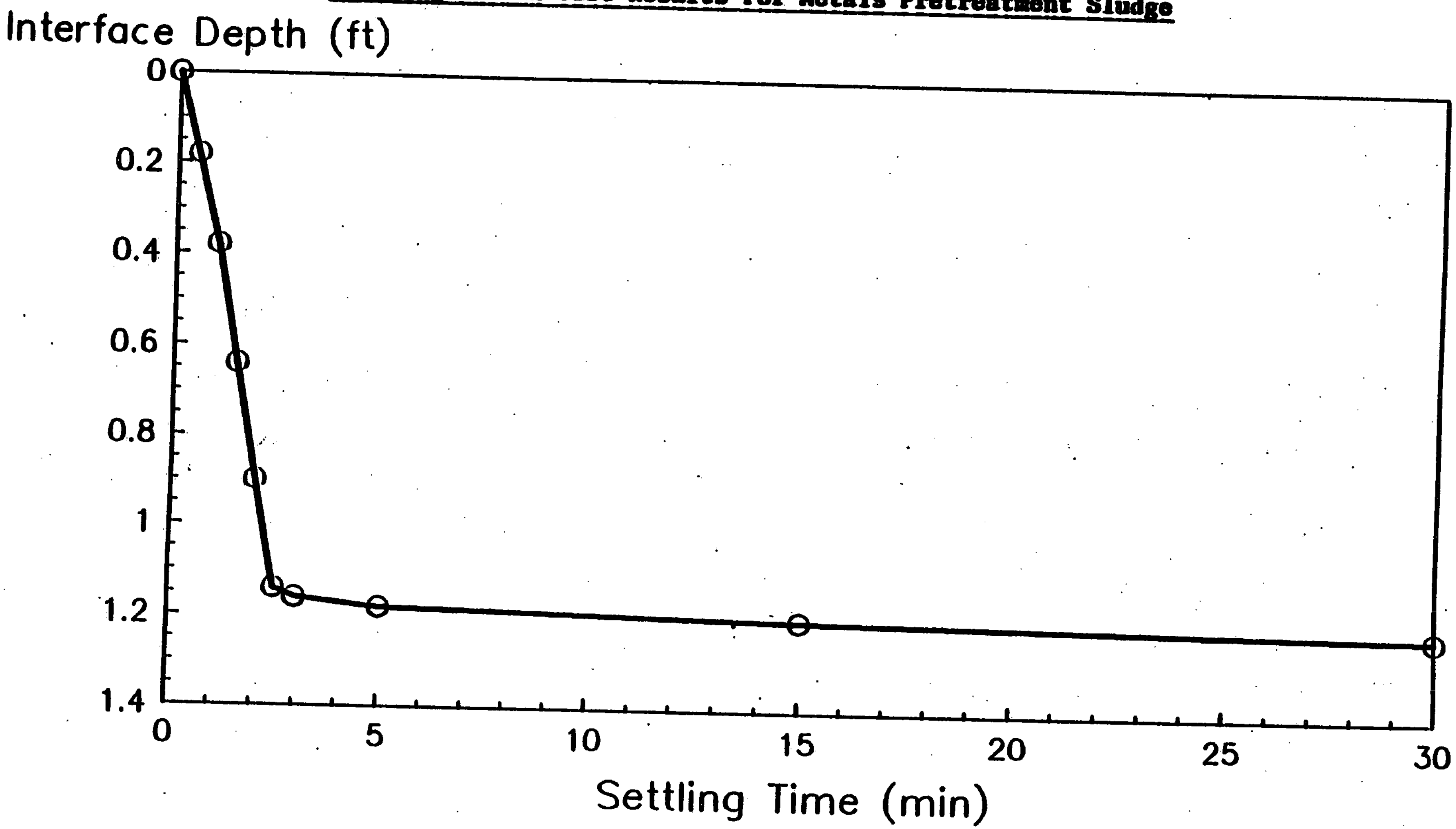


TABLE 2-10

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL REACTORS OPERATING CONDITIONS

			Cycle				
Reactor	Feed	PAC Inventory	Settle hr	Decant hr	Feed hr	Aerate hr	Cycles/ day
A	Pretreated	0 mg/l	2	1	1	8	2
C	Pretreated	125 mg/l	2	1	1	8	2
D	Raw	125 mg/l	2	1	1	8	2

Figure 2-1. The three reactors received the following feed and PAC treatments:

Reactor	Feed	PAC Inventory
A	GW Pretreated for Metals	0 mg/L
C	GW Pretreated for Metals	125 mg/L
D	Raw GW	125 mg/L

(Note: Alternative B was not tested since it was assumed that sufficient data would be generated by the other tests).

Biological solids used to seed the SBRs were obtained from the activated sludge process at the Syracuse Metropolitan Wastewater Treatment Plant. No additional solids were added to the SBRs during the course of the study.

The test reactors each received full-strength CFSL ground water from the start of the bench-scale testing. Acclimation, in the sense of step feeding ground water, was not believed necessary nor desirable, since CFSL ground water was weaker than wastewater typically encountered by the seed sludge.

The SBR feed was augmented with 2 mg/day phosphorus as phosphoric acid. Phosphorus addition was based upon an expected BOD5 concentration of 100 mg/l, a BOD5 to P ratio of 100:1, and a hydraulic retention period of 24 hours. Ammonium contained within the ground water was sufficient to meet the nitrogen requirements of the microorganisms (BOD5 to N ratio of 20:1).

PAC was introduced to reactors C and D on one occasion only. The initial PAC dosage of 125 mg/L was chosen based upon the organic loading expected for the system. The raw ground water treatment scenario was evaluated in order to assess the need for metals pretreatment.

The analytical program for the SBR study consisted of the following: weekly effluent measurements of BOD5, TOC, TSS, pH, filterable ammonia-nitrogen, and volatile organics; biweekly effluent measurements of phenol and heavy metals; and a one time effluent measurement of base-neutral and acid extractable organic compounds, total cyanides, and pesticides/PCBs.

The F/M ratios employed during treatability testing ranged from about 0.05 to 0.1 grams BOD5 per gram of MLVSS. The bench-scale biological reactors were monitored for mixed liquor volatile suspended solids (MLVSS) and effluent total organic carbon (TOC) to assess whether steady-state conditions had been achieved. MLVSS was quantified on five occasions, and effluent TOC on seven occasions, during the fifteen weeks of bench-scale biological treatability testing. Further, mixed liquor samples were microscopically inspected on several occasions. The results of these three types of monitoring were mixed with respect to identifying achievement of steady-state. Volatile solids levels were variable. However, effluent TOC and BOD5 concentrations suggest that substantial destruction of oxygen demanding organics would be achieved consistently by biological treatment.

Table 2-11 contains the results of weekly analytical testing performed on the effluent of the three SBRs. BOD5 in the raw ground water and the ground water pretreated with ferric sulfate for metals precipitation ranged from 5 to 83 mg/L and 4 to 94 mg/L, respectively, with means and standard deviations of 38 mg/L and 25 mg/L for the raw

TABLE 2-11

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - CONVENTIONAL PARAMETERS AND METALS

DATE	SAMPLE	BOD5 mg/l	TOC mg/l	TSS mg/l	VSS mg/l	NH3N mg/l	CN mg/l	PHENOL mg/l	Sb ug/l	As ug/l	Be ug/l	Cd ug/l	Cr ug/l	Cu ug/l	Fe ug/l	Pb ug/l	Hg ug/l	Ni ug/l	Se ug/l	Ag ug/l	Tl ug/l	Zn ug/l
4/12/89	---------- S T A R T - U P ----------																					
	REACTOR-A ML	-	-	2,415	1,945	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C ML	-	-	2,415	1,945	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D ML	-	-	2,415	1,945	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/26/89	RAW FEED	15	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PRET'D FEED	28	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A EFF	8	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C EFF	4	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D EFF	4	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/03/89	RAW FEED	61	58	21	-	8.8	-	-	-	-	-	-	U	U	10,900	U	-	U	-	-	-	51.2
	PRET'D FEED	31	41	27	-	7.2	-	-	-	-	-	-	U	U	U	U	-	U	-	-	-	U
	REACTOR-A EFF	8	25	15	-	1.1	-	-	-	-	-	-	U	U	231	U	-	U	-	-	-	U
	REACTOR-C EFF	6	23	12	-	2.4	-	-	-	-	-	-	U	U	838	U	-	U	-	-	-	21.9
	REACTOR-D EFF	6	24	9	-	0.4	-	-	-	-	-	-	U	U	1,050	U	-	U	-	-	-	U
	REACTOR-A ML	-	-	852	550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C ML	-	-	1,126	762	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D ML	-	-	4,606	990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/10/89	RAW FEED	55	52	18	-	8.18	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PRET'D FEED	57	56	8	-	8.64	-	0.012	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A EFF	31	20	8	-	0.28	-	0.010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C EFF	32	22	11	-	0.56	-	0.012	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D EFF	25	23	4	-	0.58	-	0.014	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 2-11

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - CONVENTIONAL PARAMETERS AND METALS

DATE	SAMPLE	BOD5 mg/l	TOC mg/l	TSS mg/l	VSS mg/l	NH3N mg/l	CN mg/l	PHENOL mg/l	Sb ug/l	As ug/l	Be ug/l	Cd ug/l	Cr ug/l	Cu ug/l	Fe ug/l	Pb ug/l	Hg ug/l	Ni ug/l	Se ug/l	Ag ug/l	Tl ug/l	Zn ug/l
5/17/89	RAW FEED	83	-	-	-	8.8	-	-	U	U	U	U	U	U	2,430	U	U	U	U	U	U	36.9
	PRET'D FEED	94	-	-	-	8.7	-	-	U	U	U	U	U	U	876	-	U	U	U	U	U	47.8
	REACTOR-A EFF	24	-	-	-	U	-	-	U	U	U	U	U	U	152	-	U	U	U	U	U	U
	REACTOR-C EFF	21	-	-	-	U	-	-	U	U	U	U	U	U	U	-	U	U	U	U	U	U
	REACTOR-D EFF	11	-	-	-	U	-	-	U	U	U	U	U	U	529	-	U	U	U	U	U	U
	REACTOR-A ML	-	-	1,090	420	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C ML	-	-	595	301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D ML	-	-	2,670	514	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/24/89	RAW FEED	9	11	18	-	8.89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PRET'D FEED	39	13	16	-	9.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A EFF	U	4	6	-	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C EFF	U	5	U	-	0.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D EFF	5	6	U	-	0.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/31/89	RAW FEED	12	-	5	-	9.76	-	0.015	-	-	-	-	U	U	224	U	-	U	-	-	-	U
	PRET'D FEED	17	-	7	-	9.51	-	0.018	-	-	-	-	U	U	223	U	-	U	-	-	-	U
	REACTOR-A EFF	9	-	-	-	0.07	-	0.012	-	-	-	-	U	U	230	U	-	U	-	-	-	U
	REACTOR-C EFF	8	-	5	-	0.09	-	0.014	-	-	-	-	U	U	190	U	-	U	-	-	-	U
	REACTOR-D EFF	4	-	-	-	0.15	-	0.012	-	-	-	-	U	U	181	U	-	U	-	-	-	U

TABLE 2-11

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - CONVENTIONAL PARAMETERS AND METALS

DATE	SAMPLE	BOD5 mg/l	TOC mg/l	TSS mg/l	VSS mg/l	NH3N mg/l	CN mg/l	PHENOL mg/l	Sb ug/l	As ug/l	Be ug/l	Cd ug/l	Cr ug/l	Cu ug/l	Fe ug/l	Pb ug/l	Hg ug/l	Ni ug/l	Se ug/l	Ag ug/l	Tl ug/l	Zn ug/l
6/07/89	RAW FEED	53	57	19	-	12.5	-	0.022	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PRET'D FEED	71	58	4	-	12.1	-	0.024	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A EFF	13	20	U	-	0.08	-	0.020	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C EFF	10	17	U	-	U	-	0.010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D EFF	12	24	U	-	0.08	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A ML	-	-	3,560	1,080	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C ML	-	-	1,620	844	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D ML	-	-	4,200	1,190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/14/89	RAW FEED	5	-	10	-	12.5	U	-	U	U	U	U	U	U	1,210	U	U	U	6.2	U	U	20.9
	PRET'D FEED	4	-	8	-	12.3	U	-	U	U	U	U	U	U	226	U	U	U	11.4	U	U	U
	REACTOR-A EFF	3	-	11	-	0.62	U	-	U	U	U	U	U	U	U	U	U	U	U	U	U	U
	REACTOR-C EFF	1	-	8	-	0.64	U	-	U	U	U	U	U	U	117	U	U	U	U	U	U	U
	REACTOR-D EFF	U	-	8	-	0.53	U	-	U	U	U	U	U	U	U	U	U	U	U	U	U	U
6/21/89	RAW FEED	45	181	47	-	11.8	-	0.031	-	-	-	-	U	U	20,100	U	-	U	-	-	-	26.1
	PRET'D FEED	16	38	7	-	12.4	-	0.034	-	-	-	-	U	U	368	U	-	U	-	-	-	U
	REACTOR-A EFF	2	19	5	-	0.32	-	0.024	-	-	-	-	U	U	U	U	-	U	-	-	-	U
	REACTOR-C EFF	7	24	3	-	0.62	-	0.019	-	-	-	-	U	U	135	U	-	U	-	-	-	U
	REACTOR-D EFF	3	23	5	-	0.42	-	0.013	-	-	-	-	U	U	120	U	-	U	-	-	-	U

TABLE 2-11

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - CONVENTIONAL PARAMETERS AND METALS

DATE	SAMPLE	BOD5 mg/l	TOC mg/l	TSS mg/l	VSS mg/l	NH3N mg/l	CN mg/l	PHENOL mg/l	Sb ug/l	As ug/l	Be ug/l	Cd ug/l	Cr ug/l	Cu ug/l	Fe ug/l	Pb ug/l	Hg ug/l	Ni ug/l	Se ug/l	Ag ug/l	Tl ug/l	Zn ug/l
6/28/89	RAW FEED	38	-	16	-	6.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PRET'D FEED	29	-	3	-	7.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A EFF	U	-	6	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C EFF	1	-	11	-	0.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D EFF	3	-	5	-	0.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A ML	-	-	2,520	702	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C ML	-	-	2,350	929	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D ML	-	-	6,980	818	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/06/89	RAW FEED	39	66.4	128	-	11.2	-	0.034	U	U	U	U	U	U	7,200	U	U	U	U	U	U	25.3
	PRET'D FEED	36	59.1	4	-	10.9	-	0.024	U	U	U	U	U	U	311	U	U	U	U	U	U	U
	REACTOR-A EFF	4	15.1	3	-	0.07	-	0.02	U	U	U	U	U	U	1,940	U	U	U	U	U	U	20.4
	REACTOR-C EFF	4	19.9	6	-	0.14	-	0.018	U	U	U	U	U	U	109	U	U	U	5.3	U	U	U
	REACTOR-D EFF	1	21.2	2	-	0.08	-	0.029	U	U	U	U	U	U	U	U	U	U	U	U	U	U
8/04/89	RAW FEED	44	52.8	22.5	-	13.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PRET'D FEED	47	55.0	2.4	-	14.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-A EFF	14	33.4	6.6	-	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-C EFF	14	29.7	U	-	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	REACTOR-D EFF	8	28.9	1.3	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

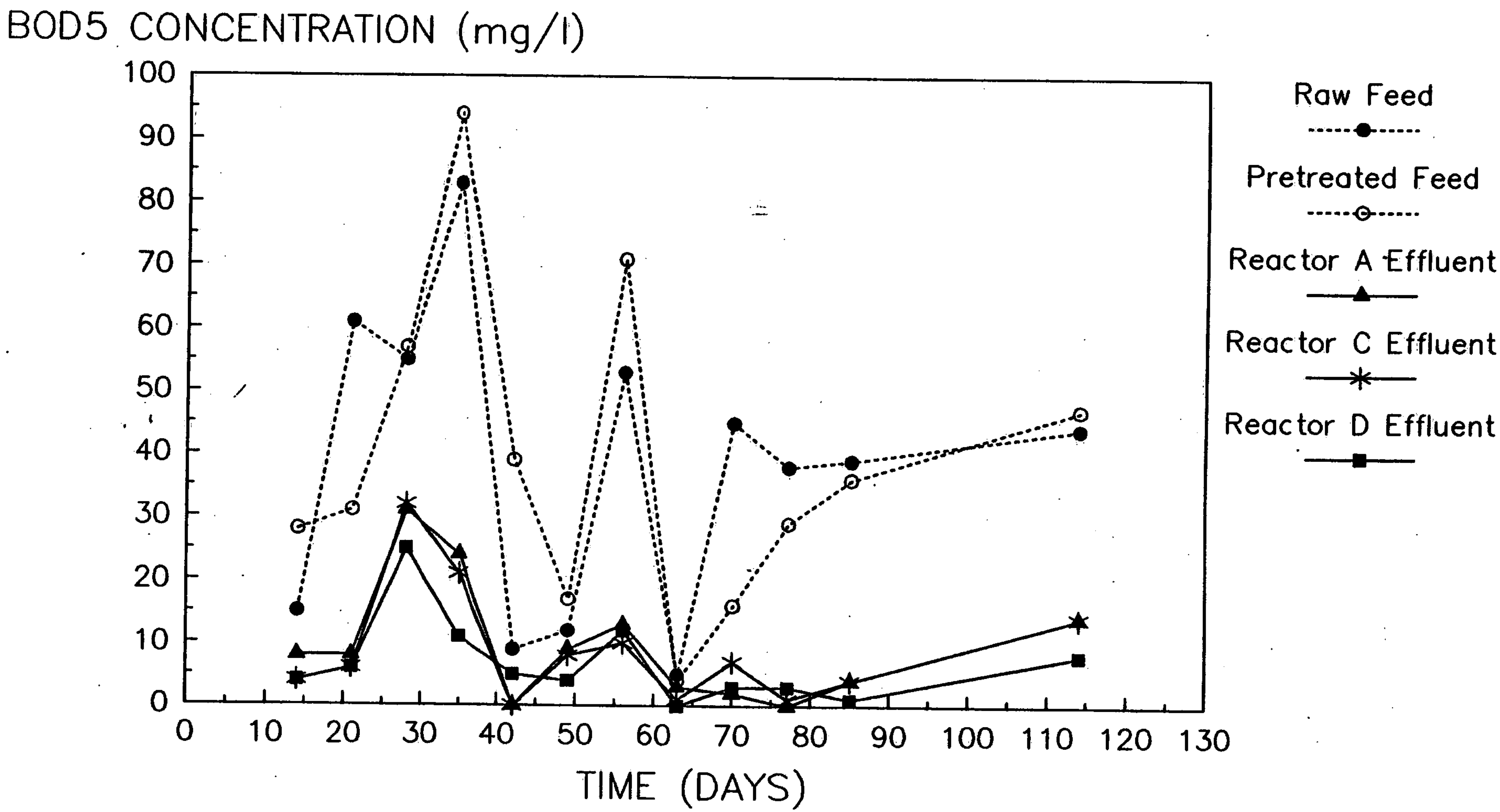
ground water samples and 38 mg/L and 26 mg/L in the pretreated ground water samples.

BOD5 was reduced in all the reactor effluents by greater than 50 percent during the course of the testing (Figure 2-4). The differences in BOD removal efficiency between ferric sulfate pretreated and raw ground water feed reactors were insignificant, indicating that metals present in the ground water do not pose a toxicity problem for biological treatment systems.

On several occasions, effluent BOD5 concentrations exceeded the daily maximum effluent discharge limitation of 20 mg/l. BOD5 excursions may be attributed to several factors, including variations in influent BOD5, and biomass population adjustments (perhaps both in quantity and types) during the initial weeks of operation. Metals-pretreated feed BOD5 varied from 15 mg/l to 83 mg/l, with greater values occurring coincident with effluent BOD5 excursions. Such fluctuations in ground water BOD5 would not be expected with a full-scale ground water recovery system, due to the number of necessary wells, and the gradual fluctuations in ground water quality expected on a day-to-day basis. Further BOD5 removal is expected in filtration and carbon adsorption processes downstream from the SBRs. At the 95 percent confidence level, there is no significant difference between the three reactors' effluent BOD5 concentrations.

TSS loadings to the SBRs fluctuated with time ranging from 3 to 47 mg/L for the raw ground water and 3 to 27 mg/L for the ferric sulfate pre-treated ground water. The lower TSS of the ferric sulfate ground water results from TSS removal during pretreatment. The removal trends of TOC and TSS generally followed those of BOD5 with

FIGURE 2-4
INFLUENT AND EFFLUENT BOD5



only insignificant differences between the different treatment scenarios. Ammonia-nitrogen levels were generally reduced from feed concentrations which ranged from 7.0 to 12.5 mg/L to generally less than 1 mg/L. Phenols were not detected (less than 0.05 mg/l) in any of the influent or effluent samples.

Zinc, present in the raw feed at concentrations ranging from less than the 5 ug/L detection limit to 51 ug/L, was typically reduced to less than the detection limit via biological treatment. These results suggest that biological treatment of the raw ground water may be adequate to treat heavy metals. However, higher metals concentrations in ground water may be evident in the future, therefore metal pretreatment by iron hydroxide co-precipitation would be a prudent precursor to biological treatment.

Table 2-12 contains the results of weekly volatile organic compound scans of SBR influents and effluents. VOCs present in the SBR influents were methylene chloride, 1,2 dichloroethane, benzene, toluene, chlorobenzene, and ethylbenzene which ranged from 3 to 8 ug/L, undetectable (UD) to 91 ug/L, UD to 10 ug/L, 9 to 140 ug/L, 6 to 25 ug/L, and 2 to 27 ug/L, respectively. These volatile organic compounds were generally reduced to less than the method detection limit in all the SBR effluents for the duration of the study.

Tables 2-13, 2-14, and 2-15 present the results of analytical testing for base neutral extractables, acid extractables, and pesticides/PCBs, respectively. The one time analysis of base neutral and acid extractable organics and pesticides/PCBs indicate that these compounds were not detectable in either the raw or pretreated feeds nor were these compounds detectable in the effluents from the SBRs.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

MAY 03, 1989

COMPOUND (ug/l)	INFLUENT		EFFLUENT		
	RAW	PRET'D	REACTOR-A	REACTOR-C	REACTOR-D
Chloromethane	U	U	U	U	U
Bromomethane	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U
Chloroethane	U	U	U	U	U
Methylene Chloride	5	6	4J	4J	4J
Trichlorofluoromethane	U	U	U	U	U
Acrolein	U	U	U	U	U
Acrylonitrile	U	U	U	U	U
1,1-Dichloroethene	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U
Chloroform	U	U	U	U	U
1,2-Dichloroethane	U	31	U	U	U
1,1,1-Trichloroethane	U	U	2J	3J	2J
Carbon Tetrachloride	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U
c-1,3-Dichloropropene	U	U	U	U	U
2-Chloroethylvinylether	U	U	U	U	U
Trichloroethene	U	U	U	U	U
Dirbromochloromethane	U	U	U	U	U
1,1,2-Trichloroethane	U	U	U	U	U
Benzene	10	6	U	U	U
t-1,3-Dichloropropene	U	U	U	U	U
Bromoform	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
1,1,2,2-Tetrachloroethane	U	U	U	U	U
Toluene	42	63	U	U	U
Chlorobenzene	25	11	U	U	U
Ethylbenzene	5	11	U	U	U

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

MAY 10, 1989

COMPOUND (ug/l)	INFLUENT		EFFLUENT		
	RAW	PRET'D	REACTOR-A	REACTOR-C	REACTOR-D
Chloromethane	U	U	U	U	U
Bromomethane	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U
Chloroethane	U	U	U	U	U
Methylene Chloride	4JB	4JB	7B	8B	7B
Trichlorofluoromethane	U	U	U	U	U
Acrolein	U	U	U	U	U
Acrylonitrile	U	U	U	U	U
1,1-Dichloroethene	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U
Chloroform	U	U	U	U	U
1,2-Dichloroethane	41	91	U	U	U
1,1,1-Trichloroethane	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U
c-1,3-Dichloropropene	U	U	U	U	U
2-Chloroethylvinylether	U	U	U	U	U
Trichloroethene	U	U	U	U	U
Dirbromochloromethane	U	U	U	U	U
1,1,2-Trichloroethane	U	U	U	U	U
Benzene	7	8	U	U	U
t-1,3-Dichloropropene	U	U	U	U	U
Bromoform	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
1,1,2,2-Tetrachloroethane	U	U	U	U	U
Toluene	57	69	U	U	U
Chlorobenzene	17	14	U	U	U
Ethylbenzene	11	19	U	U	U

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

MAY 17, 1989

COMPOUND (ug/l)	INFLUENT RAW	INFLUENT PRET'D	EFFLUENT REACTOR-A	EFFLUENT REACTOR-C	EFFLUENT REACTOR-D
Chloromethane	U	U	U	U	U
Bromomethane	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U
Chloroethane	U	U	U	U	U
Methylene Chloride	4JB	4JB	2JB	3JB	2JB
Trichlorofluoromethane	U	U	U	U	U
Acrolein	U	U	U	U	U
Acrylonitrile	U	U	U	U	U
1,1-Dichloroethene	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U
Chloroform	U	U	U	U	U
1,2-Dichloroethane	24	66	U	U	3J
1,1,1-Trichloroethane	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U
c-1,3-Dichloropropene	U	U	U	U	U
2-Chloroethylvinylether	U	U	U	U	U
Trichloroethene	U	U	U	U	U
Dirbromochloromethane	U	U	U	U	U
1,1,2-Trichloroethane	U	U	U	U	U
Benzene	7	8	U	U	U
t-1,3-Dichloropropene	U	U	U	U	U
Bromoform	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
1,1,2,2-Tetrachloroethane	U	U	U	U	U
Toluene	48	140	U	U	U
Chlorobenzene	14	13	U	U	U
Ethylbenzene	8	14	U	U	U

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

MAY 31, 1989

COMPOUND (ug/l)	INFLUENT		EFFLUENT		
	RAW	PRET'D	REACTOR-A	REACTOR-C	REACTOR-D
Chloromethane	U	U	U	U	U
Bromomethane	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U
Chloroethane	U	U	U	U	U
Methylene Chloride	3J	4J	5	5	5
Trichlorofluoromethane	U	U	U	U	U
Acrolein	U	U	U	U	U
Acrylonitrile	U	U	U	U	U
1,1-Dichloroethene	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U
Chloroform	U	U	U	U	U
1,2-Dichloroethane	22	7	U	U	U
1,1,1-Trichloroethane	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U
c-1,3-Dichloropropene	U	U	U	U	U
2-Chloroethylvinylether	U	U	U	U	U
Trichloroethene	U	U	U	U	U
Dirbromochloromethane	U	U	U	U	U
1,1,2-Trichloroethane	U	U	U	U	U
Benzene	6	6	U	U	U
t-1,3-Dichloropropene	U	U	U	U	U
Bromoform	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
1,1,2,2-Tetrachloroethane	U	U	U	U	U
Toluene	42	22	U	U	U
Chlorobenzene	15	15	U	U	U
Ethylbenzene	27	9	U	U	U

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

JUNE 7, 1989

COMPOUND (ug/l)	INFLUENT		EFFLUENT		
	RAW	PRET'D	REACTOR-A	REACTOR-C	REACTOR-D
Chloromethane	U	U	U	U	U
Bromomethane	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U
Chloroethane	U	U	U	U	U
Methylene Chloride	U	3J	3J	U	3J
Trichlorofluoromethane	U	U	U	U	U
Acrolein	U	U	U	U	U
Acrylonitrile	U	U	U	U	U
1,1-Dichloroethene	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U
Chloroform	U	U	U	U	U
1,2-Dichloroethane	22	7	U	U	U
1,1,1-Trichloroethane	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U
c-1,3-Dichloropropene	U	U	U	U	U
2-Chloroethylvinylether	U	U	U	U	U
Trichloroethene	U	U	U	U	U
Dirbromochloromethane	U	U	U	U	U
1,1,2-Trichloroethane	U	U	U	U	U
Benzene	4J	U	U	U	U
t-1,3-Dichloropropene	U	U	U	U	U
Bromoform	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
1,1,2,2-Tetrachloroethane	U	U	U	U	U
Toluene	12	9	U	U	U
Chlorobenzene	18	13	U	U	U
Ethylbenzene	3J	2J	U	U	U

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

JUNE 21, 1989

COMPOUND (ug/l)	INFLUENT		EFFLUENT		
	RAW	PRET'D	REACTOR-A	REACTOR-C	REACTOR-D
Chloromethane	U	U	U	U	U
Bromomethane	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U
Chloroethane	U	U	U	U	U
Methylene Chloride	U	8	U	U	U
Trichlorofluoromethane	U	U	U	U	U
Acrolein	U	U	U	U	U
Acrylonitrile	U	U	U	U	U
1,1-Dichloroethene	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U
Chloroform	U	U	U	U	U
1,2-Dichloroethane	U	U	U	U	U
1,1,1-Trichloroethane	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U
c-1,3-Dichloropropene	U	U	U	U	U
2-Chloroethylvinylether	U	U	U	U	U
Trichloroethene	U	U	U	U	U
Dirbromochloromethane	U	U	U	U	U
1,1,2-Trichloroethane	U	U	U	U	U
Benzene	3J	3J	U	U	U
t-1,3-Dichloropropene	U	U	U	U	U
Bromoform	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
1,1,2,2-Tetrachloroethane	U	U	U	U	U
Toluene	28	110	U	U	U
Chlorobenzene	14	6	U	U	U
Ethylbenzene	2J	5	U	U	U

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

JUNE 28, 1989

COMPOUND (ug/l)	INFLUENT RAW	INFLUENT PRET'D	EFFLUENT REACTOR-A	EFFLUENT REACTOR-C	EFFLUENT REACTOR-D
Chloromethane	U	-	-	-	-
Bromomethane	U	-	-	-	-
Vinyl Chloride	U	-	-	-	-
Chloroethane	U	-	-	-	-
Methylene Chloride	3J	-	-	-	-
Trichlorofluoromethane	U	-	-	-	-
Acrolein	U	-	-	-	-
Acrylonitrile	U	-	-	-	-
1,1-Dichloroethene	U	-	-	-	-
1,1-Dichloroethane	U	-	-	-	-
1,2-Dichloroethene (total)	U	-	-	-	-
Chloroform	U	-	-	-	-
1,2-Dichloroethane	22	-	-	-	-
1,1,1-Trichloroethane	U	-	-	-	-
Carbon Tetrachloride	U	-	-	-	-
Bromodichloromethane	U	-	-	-	-
1,2-Dichloropropane	U	-	-	-	-
c-1,3-Dichloropropene	U	-	-	-	-
2-Chloroethylvinylether	U	-	-	-	-
Trichloroethene	9	-	-	-	-
Dirbromochloromethane	U	-	-	-	-
1,1,2-Trichloroethane	U	-	-	-	-
Benzene	3J	-	-	-	-
t-1,3-Dichloropropene	U	-	-	-	-
Bromoform	U	-	-	-	-
Tetrachloroethene	U	-	-	-	-
1,1,2,2-Tetrachloroethane	U	-	-	-	-
Toluene	34	-	-	-	-
Chlorobenzene	16	-	-	-	-
Ethylbenzene	2J	-	-	-	-

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-12

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - VOLATILE ORGANICS

JULY 6, 1989

COMPOUND (ug/l)	INFLUENT		EFFLUENT		
	RAW	PRET'D	REACTOR-A	REACTOR-C	REACTOR-D
Chloromethane	U	U	U	U	U
Bromomethane	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U
Chloroethane	U	U	U	U	U
Methylene Chloride	U	U	U	U	U
Trichlorofluoromethane	U	U	U	U	U
Acrolein	U	U	U	U	U
Acrylonitrile	U	U	U	U	U
1,1-Dichloroethene	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U
Chloroform	U	U	U	U	U
1,2-Dichloroethane	U	U	U	U	U
1,1,1-Trichloroethane	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U
c-1,3-Dichloropropene	U	U	U	U	U
2-Chloroethylvinylether	U	U	U	U	U
Trichloroethene	U	U	U	U	U
Dirbromochloromethane	U	U	U	U	U
1,1,2-Trichloroethane	U	U	U	U	U
Benzene	7	3J	U	U	U
t-1,3-Dichloropropene	U	U	U	U	U
Bromoform	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
1,1,2,2-Tetrachloroethane	U	U	U	U	U
Toluene	43	27	U	U	U
Chlorobenzene	25	11	U	U	U
Ethylbenzene	7	7	U	U	U

J - Detected but less than method detection limit.
U - Undetected.
B - Also detected in blank.

TABLE 2-13

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - BASE/NEUTRAL EXTRACTABLE ORGANICS

JUNE 1, 1989

COMPOUNDS	DETECTION LIMITS ug/l	INFLUENT RAW ug/l	INFLUENT PRET'D ug/l	EFFLUENT REACTOR A ug/l	EFFLUENT REACTOR C ug/l	EFFLUENT REACTOR D ug/l
N-Nitrosodimethylamine	10	U	U	U	U	U
Bis (2-chloroethyl) ether	10	U	U	U	U	U
1,3-Dichlorobenzene	10	U	U	U	U	U
1,4-Dichlorobenzene	10	U	3J	U	U	U
1,2-Dichlorobenzene	10	2J	2J	U	U	U
Bis (2-chloroisopropyl) ether	10	U	U	U	U	U
Hexachloroethane	10	U	U	U	U	U
N-Nitrosodi-n-propylamine	10	U	U	U	U	U
Nitrobenzene	10	U	U	U	U	U
Isophorone	10	U	U	U	U	U
Bis (2-chloroethoxy) methane	10	U	U	U	U	U
1,2,4-Trichlorobenzene	10	U	U	U	U	U
Naphthalene	10	5J	1J	U	U	U
Hexachlorobutadiene	10	U	U	U	U	U
Hexachlorocyclopentadiene	10	U	U	U	U	U
2-Chloronaphthalene	10	U	U	U	U	U
Dimethyl phthalate	10	U	U	U	U	U
Acenaphthalene	10	U	U	U	U	U
2,6-Dinitrotoluene	10	U	U	U	U	U
Acenaphthene	10	U	U	U	U	U
2,4-Dinitrotoluene	10	U	U	U	U	U
Diethylphthalate	10	2J	3J	U	1J	U
Fluorene	10	U	U	U	U	U
4-Chlorophenyl phenyl ether	10	U	U	U	U	U
4-Bromophenyl phenyl ether	10	U	U	U	U	U
N-nitrosodiphenylamine	10	U	U	U	U	U
Hexachlorobenzene	10	U	U	U	U	U
Phenanthrene	10	U	U	U	U	U
Anthracene	10	U	U	U	U	U
Di-n-butyl phthalate	10	0.3J	U	U	U	U
Fluoranthene	10	U	U	U	U	U
Benzidine	80	U	U	U	U	U
Pyrene	10	U	U	U	U	U
Butyl benzyl phthalate	10	U	U	U	U	U
3,3-Dichlorobenzidine	20	U	U	U	U	U
Chrysene	10	U	U	U	U	U
Benzo(a)anthracene	10	U	U	U	U	U
Bis (2-ethylhexyl) phthalate	10	2JB	240B	28B	34B	430B
Di-n-octylphthalate	10	U	U	U	U	U
Benzo(b)fluoranthene	10	U	U	U	U	U
Benzo(k)fluoranthene	10	U	U	U	U	U
Benzo(a)pyrene	10	U	U	U	U	U
Benzo(g,h,i)perylene	10	U	U	U	U	U
Dibenzo(a,h)anthracene	10	U	U	U	U	U
Indeno(1,2,3-cd)pyrene	10	U	U	U	U	U
1,2-diphenylhydrazine(2)	10	U	-	-	-	-

J - Detected but less than method detection limit.
U - Undetected.
B - Also detcted in blank.

TABLE 2-14

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS - ACID EXTRACTABLE ORGANICS

JUNE 1, 1989

COMPOUNDS	DETECTION LIMITS ug/l	INFLUENT RAW ug/l	INFLUENT PRET'D ug/l	EFFLUENT REACTOR A ug/l	EFFLUENT REACTOR C ug/l	EFFLUENT REACTOR D ug/l
phenol	10	U	U	U	U	U
2-chlorophenol	10	U	U	U	U	U
2-nitrophenol	10	U	U	U	U	U
2,4-dimethylphenol	10	U	U	U	U	U
2,4-dichlorophenol	10	U	U	U	U	U
4-chloro-3-methyl phenol	10	U	U	U	U	U
2,4,6-trichlorophenol	10	U	U	U	U	U
2,4-dinitrophenol	50	U	U	U	U	U
4-nitrophenol	50	U	U	U	U	U
2-methyl-4,6-dinitrophenol	50	U	U	U	U	U
pentachlorophenol	50	U	U	U	U	U

U - Undetected

TABLE 2-15

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

BENCH-SCALE BIOLOGICAL TESTING ANALYTICAL RESULTS
PESTICIDES/PCBs

COMPOUNDS	DETECTION LIMITS ug/l	RAW FEED ug/l	PRETREATED FEED ug/l
alpha BHC	0.01	U	U
beta BHC	0.01	U	U
gamma BHC	0.01	U	U
delta BHC	0.01	U	U
Heptachlor	0.01	U	U
Aldrin	0.01	U	U
4,4'DDE	0.01	U	U
Dieldrin	0.01	U	U
4,4'DDD	0.05	U	U
Endrin aldehyde	0.05	U	U
4,4'DDT	0.05	U	U
Chlordane	0.10	U	U
Endosulfan I	0.05	U	U
Endosulfan II	0.05	U	U
Endosulfan sulfate	0.05	U	U
Heptachlor epoxide	0.01	U	U
Toxaphene	1.00	U	U
PCB - 1016	0.20	U	U
PCB - 1221	0.20	U	U
PCB - 1232	0.20	U	U
PCB - 1242	0.20	U	U
PCB - 1248	0.20	U	U
PCB - 1254	0.20	U	U
PCB - 1260	0.20	U	U

U - Undetected

2.08 Activated Carbon Adsorption

Carbon adsorption isotherm testing employing PAC was substituted for granular activated carbon (GAC) column testing because column testing would have required an unavailable volume of low strength SBR effluent. PAC was obtained by pulverizing Calgon FS-400 GAC through a 200 mesh sieve (particle size less than 75 um). An adsorption isotherm was developed using effluent from Reactor A. Reactor A effluent was employed because it had not been enhanced with PAC and because it best represented the anticipated full scale treatment system.

Five dosages of PAC ranging from 0 to 200 mg/L were added to 200 ml of Reactor A treated ground water. Each container was vigorously mixed for 2 hours. The resulting supernatants were filtered through a 0.45 um filter and analyzed for TOC.

The PAC adsorption isotherm test results are presented in Table 2-16. Extrapolation of these results indicates that carbon adsorption is capable of reducing SBR effluent to TOC concentrations below effluent discharge limitations of 10 mg/L.

The average SBR effluent TOC concentration for all reactors over the course of the study was approximately 20 mg/L. The batch powdered activated carbon test results indicate that effluent TOC can be reduced to below effluent discharge limitations by carbon adsorption, given activated carbon dosages of 200 mg/l or greater.

2.09 Solids Handling

The Conceptual Design Report (1) indicated that the Parsippany-Troy Hills Wastewater Treatment Plant (WWTP) possessed excess solids handling capacity and might be willing to accept sludge

TABLE 2-16

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

PAC ADSORPTION ISOTHERM
TEST RESULTS

PAC (mg/l)	Final TOC (mg/l)
0	22.4
30	22.5
50	16.0
100	13.0
200	10.2

generated from the ground water treatment facility. Sludge dewatering tests were to be conducted (per the Field Sampling and Testing Plan - November 1988) using a volume proportionate mixture of sludge from the Parsippany-Troy Hills Wastewater Treatment Plant (WWTP) and that generated during biological testing of Combe Fill South Landfill ground water. WWTP officials contacted by telephone indicated that they would not be interested in processing sludge generated by the full-scale Combe Fill South Landfill ground water treatment facility. WWTP officials did not cooperate in supplying sludge for testing. The sludge generated from the bench-scale SBRs was not sufficient to perform sludge dewaterability testing. Therefore, dewaterability of bench-scale sludges was not tested and filter cake was not generated. Since a filter cake was not available, no sludge samples were tested for heavy metals or volatile organics.

It is proposed that primary sludge from metals pretreatment and waste activated sludge generated by the full-scale Combe Fill South Landfill ground water treatment facility will be dewatered on-site by pressure filtration. The full-scale system filter cake is not anticipated to be a characteristic hazardous waste.

Table 2-17 presents the recently promulgated toxicity characteristic maximum concentrations along with predicted maximum allowable ground water concentrations of toxicity characteristic substances based on expected ground water flow, daily filter cake mass, solids concentration and an assumed 100 percent transfer of contaminants in the ground water to the filter cake. Each maximum allowable ground water concentration is a level which, if exceeded, would cause the filter cake to exceed the toxicity characteristic maximum concentration for that substance. With the exception of the highest observed concentrations

TABLE 2-17
COMBE FILL SOUTH LANDFILL
MAXIMUM ALLOWABLE GROUND WATER CONCENTRATIONS

	Maximum Concentration of Contaminants for the Toxicity Characteristic (mg/l)	Allowable Headworks Loading Based on Prevention of Toxicity Characteristics (lbs/day)	175,000 gpd (ug/l)	Ground Water Characteristics* (1986 - 1988) (ug/l)	(1989) (ug/l)
Arsenic	5.0	0.58	397.40	U - 88.7	U
Barium	100.0	11.60	7947.93	12.28 - 574	NA
Benzene	0.5	0.06	39.74	U - 80.2	3J - 10
Cadmium	1.0	0.12	79.48	U - 10.1	U
Carbon Tetrachloride	0.5	0.06	39.74	NA	U
Chlordane	0.03	0.003	2.38	NA	NA
Chlorobenzene	100.0	11.60	7947.93	U - 52	14 - 25
Chloroform	6.0	0.70	476.88	U - 57.5	U
Chromium	5.0	0.58	397.40	U - 30.1	25.8
o-Cresol	200.0	23.20	15895.85	NA	NA
m-Cresol	200.0	23.20	15895.85	NA	NA
p-Cresol	200.0	23.20	15895.85	NA	NA
Cresol	200.0	23.20	15895.85	NA	NA
2,4-D	10.0	1.16	794.79	NA	NA
1,4-Dichlorobenzene	7.5	0.87	596.09	U - 39.4	U
1,2-Dichloroethane	0.5	0.06	39.74	U - 6.1	U - 41
1,1-Dichloroethylene	0.7	0.08	55.64	U	U
2,4-Dinitrotoluene	0.13	0.02	10.33	NA	U
Endrin	0.02	0.002	1.59	NA	U
Heptachlor	0.008	0.001	0.64	NA	U
Hexachlorobenzene	3.0	0.35	238.44	NA	U
Hexachlorobutadiene	0.5	0.06	39.74	NA	U
Hexachloroethane	3.0	0.35	238.44	NA	U
Lead	5.0	0.58	397.40	U - 37.2	U - 5.5
Lindane	0.4	0.05	31.79	NA	NA
Mercury	0.2	0.02	15.90	U - 0.2	U
Methoxychlor	10.0	1.16	794.79	NA	NA
Methyl ethyl ketone	200.0	23.20	15895.85	NA	NA
Nitrobenzene	2.0	0.23	158.96	NA	U

TABLE 2-17
COMBE FILL SOUTH LANDFILL
MAXIMUM ALLOWABLE GROUND WATER CONCENTRATIONS

	Maximum Concentration of Contaminants for the Toxicity Characteristic (mg/l)	Allowable Headworks Loading Based on Prevention of Toxicity Characteristics (lbs/day)	175,000 gpd (ug/l)	Ground Water Characteristics* (1986 - 1988) (ug/l)	(1989) (ug/l)
Pentachlorophenol	100.0	11.60	7947.93	NA	U
Pyridine	5.0	0.58	397.40	NA	NA
Selenium	1.0	0.12	79.48	U - 5.0	U - 6.2
Silver	5.0	0.58	397.40	U - 10.0	U
Tetrachloroethylene	0.7	0.08	55.64	U - 4.1	NA
Toxaphene	0.5	0.06	39.74	NA	U
Trichloroethylene	0.5	0.06	47.96	U - 4.0	U
2,4-5-Trichlorophenol	400.0	46.40	38369.30	NA	NA
2,4,6-Trichlorophenol	2.0	0.23	191.85	NA	U
2,4,5-TP	1.0	0.12	95.92	NA	NA
Vinyl Chloride	0.2	0.02	19.18	U - 10.0	U

*From Tables 2-1, 2-2, 2-8, 2-11, 2-12, 2-13, 2-14, and 2-15
J - Detected but less than method limit
U - Undetected
B - Also detected in blank
NA - Not Analyzed

Calculation of Allowable headworks loading based on prevention of TCLP Toxicity:

$$\text{ALLOWABLE HEADWORKS LOADING (lbs/day)} = \frac{(V)(Chc)(Msl)}{(R)(M)(PS)}$$

V = Volume of liquid in test (2 liters)
Chc = Concentration of contaminant for TCLP hazardous classification (mg/l)
Msl = Mass of sludge generated (1740 lbs/day)
R = Removal in treatment plant (Conservative estimate = 100 percent/100)
M = Mass of sample in test (100,000 milligrams)
PS = Concentration of sludge solids (30 percent/100)

the exception of the highest observed concentrations of benzene and 1,2-dichloroethane, each predicted maximum allowable ground water concentration is greater than actual ground water characteristics, indicating that sludge produced would not be hazardous as defined by the TCLP test. Benzene and 1,2-dichloroethane concentrations should not render the filter cake hazardous by the toxicity characteristic since biological oxidation and volatilization of benzene in the biological treatment system will yield a very low mass transfer efficiency from the ground water to the sludge.

2.10 Effluent Toxicity Testing

Both acute and chronic toxicity testing was conducted on fish and invertebrates using effluent from treatability testing Alternate C. This effluent was Combe Fill South Landfill shallow ground water which had been pretreated for metals by chemical coprecipitation and treated by a PAC enhanced biological suspended growth sequencing batch reactor.

Toxicity testing consisted of 96 hour static renewal bioassays employing both fathead minnows (Pimephales promelas) and *Daphnia magna*. Acute toxicity testing was conducted by O'Brien & Gere Engineers, Inc. in its Syracuse, New York toxicity testing facilities. Concentrations of treated effluent varying from 100 to 0 percent were prepared using dilution water obtained from just downstream of the confluence of the east and west branches of Trout Brook. This location was identified by NJDEP as the expected discharge point of the ground water treatment facility, and, as such, represented the receiving water to be utilized in the test method. The percent mortality of the two biological indicators was recorded after 96 hours and the corresponding LC-50s were calculated. Test conditions are detailed in Appendix 1.

The results of the acute toxicity testing performed on the effluent from the bench-scale SBRs are presented in Table 2-18. Based upon the 15 percent mortality demonstrated in 100 percent of the sample, the LC-50s for the treated ground water are greater than 100 percent for both the vertebrate (fathead minnows) and the invertebrate (Daphnia magna) species. The data also indicate that the dilution water obtained from Trout Brook is toxic to the Daphnia magna as indicated by the 100 percent mortality produced by concentrations of dilution water exceeding 75 percent. Because the dilution water was toxic, the control mortality was in excess of 10 percent which is outside NJDEP control limits for the test.

Although the bioassay did not meet the QA/QC acceptance criteria due to the toxic dilution water (receiving stream), the test was properly conducted and provided data useful to the project. These data indicate that the effluent from the proposed ground water treatment facility should not pose a significant environmental hazard upon discharge to Trout Brook.

Chronic toxicity testing performed on the effluent from the bench-scale SBRs was performed in accordance with the NJDEP interim chronic toxicity testing methodology. Chronic toxicity testing was performed by International Technology Corp. of Edison, New Jersey. The chronic testing was accomplished utilizing short-term tests on fathead minnows (Pimephales promelas) and water fleas (Ceriodaphnia dubia). The results of the chronic tests demonstrate the effluent to be of low chronic toxicity (Exhibit A). In both the fathead minnow and

TABLE 2-18

COMBE FILL SOUTH LANDFILL
GROUND WATER TREATABILITY STUDY

96-HOUR ACUTE BIOASSAY TEST RESULTS *

Effluent Conc. (%)	Percent Survival	
	Fathead Minnows	Daphnia Magna
100	85	85
50	75	90
25	75	95
12.5	75	0
6.25	90	0
0	80	0

* Effluent produced from treatment alternative C involving metals pretreatment followed by PAC enhanced SBR biological treatment of ground water. Effluent diluted with water obtained from Trout Brook, the proposed receiving water.

Ceriodaphnia tests, measurable effects were observed in the 100 percent effluent samples only, with no effects measured at subsequent dilutions. In the fathead minnows, the only effect observed was mortality, with a calculated LC_{50} of 92.9 percent of effluent. The Ceriodaphnia test did not show measurable toxicity, but demonstrated reproductive effects in two 100 percent effluent samples only. The results of these tests suggest that, following minimal dilution, the effluent discharged would not be expected to cause adverse aquatic impacts.

2.11 Recommended Treatment System

The treatability study was formulated to assess the efficacy and efficiency of the four different treatment alternatives presented in Figure 2-1. The alternatives were constructed based upon ground water quality data generated during the RI and the IEMP, and address the treatment of the different contaminants found at the site including heavy metals, volatile organic substances, and BOD5.

Ground water obtained for the treatability study contained lower concentrations of BOD5, TSS, VOCs, and heavy metals, than had been expected based upon previous studies conducted at the site. All the alternatives performed comparably in removing ground water contaminants. Heavy metals were effectively removed and tolerated in biological systems, whether or not the raw ground water was pretreated for metals by chemical co-precipitation. Volatile organics were eliminated from the ground water in all SBR reactor configurations including the one without PAC. BOD5 removals were consistent between the different treatment scenarios indicating that neither heavy metal nor other contaminant toxicity posed an operational problem for the biological systems.

In light of the temporal variability in ground water quality and the unknown quality of landfill gas condensate requiring treatment, a high degree of conservatism is required in the design of the ground water treatment system. Hence, Treatment Alternative A (Figure 2-1) which includes metals pretreatment, biological treatment with SBRs, filtration, and GAC adsorption polishing has been selected as the treatment strategy. Further, it is recommended that PAC dosage capabilities be provided for the SBRs.

The selected treatment strategy (Treatment Alternative A) incorporates processes designed to enhance the system's ability to consistently meet all discharge limits. Specifically, unit processes including sand filters and GAC adsorption units are included to minimize the possibility of effluent excursions. The SBR design was chosen over other biological treatment system configurations because it is relatively easy to operate and offers more operational flexibility than other designs such as continuous flow activated sludge. Operational flexibility is critical considering the long-term changes in ground water quality and quantity anticipated. During the treatability study pretreatment was not a significant factor in the removal of heavy metals from ground water. However, due to the expected long-term variability in ground water quality and the history of ground water heavy metals contamination at the site, metals pretreatment has been included in the design of the treatment system.

Landfill gas condensate (LGC) is expected to be an important component of liquids requiring treatment at the Combe Fill South

TABLE 2-19

COMBE FILL SOUTH LANDFILL

RECOMMENDED TREATMENT SYSTEM

Unit Operation	Rationale For Selection
Landfill Gas Condensate Aerated Equalization	Dampens effects on downstream process system resulting from variations in landfill condensate loadings and flow. Provides a location for segregation and alternative handling (e.g. transport and off-site treatment).
Influent Flow Equalization	Dampens effects on downstream process system resulting from variations in loadings and flow. Provides short-term emergency storage. Allows for batch operation (one shift) of the entire treatment facility as flows reduce over time.
Metals Removal System	Provides for removal of heavy metals and other particulates.
Biological Treatment with SBRs	Provides for removal of organics (BOD_5, TOC, volatile organics and phenolics), and ammonia. Selected for effluent quality achievable, operational flexibility and low operator attention. Operational flexibility is considered critical considering the long-term changes in ground water quality and quantity anticipated.
Optional PAC Enhancement of SBRs	Provides enhanced flexibility for treatment of high-strength ground water or leachate.
Filtration	Provides for removal of suspended solids to assure compliance with effluent limitations and to prolong carbon adsorption bed life.
Carbon Adsorption	Provides for removal of trace organics to a level consistent with discharge objectives.
Sludge Dewatering	Achieves acceptable and cost effective solids content prior to off-site disposal.

TABLE 2-20

COMBE FILL SOUTH LANDFILL
SUPERFUND SITE REMEDIAL DESIGN
GW/CONDENSATE TREATMENT
PRELIMINARY BASIS OF DESIGN MASS BALANCE

Key to Mass Balance Locations

1 - Equalized Condensate

2 - Raw GW
3 - Equalized GW
4 - SBR Feed
5 - Primary Sludge

6 - SBR Effluent
7 - SBRs WAS

8 - Filter Effluent
9 - Filter Backwash

10 - GAC Columns Effluent
11 - GAC Backwash
12 - Spent Carbon

13 - GW WAS, and GW PS
14 - Filter Backwash, Backwash and Filtrate to GW Equalization Tank
15 - Filter Cake

Landfill. NJDEP expects LGC to be similar to that of the sample characterized (Table 2-6), and therefore requests that the design reflect this expectation. Therefore, it is proposed that a 25,000 gallon aerated condensate equalization tank be employed for pretreatment of the LGC. The condensate will be equalized and aerated in this tank prior to discharge to the downstream SBRs. The SBRs are not expected to accommodate 5,000 gpd of typical strength LGC (per the literature; Table 2-5). The condensate equalization tank will, therefore, be equipped with fittings to allow for pumping of condensate to a tanker truck for transport to an off-site disposal facility, if required.

The processes included for ground water treatment include flow equalization, heavy metals co-precipitation, biological treatment in SBRs, filtration of SBR effluent, GAC adsorption polishing and gravity discharge to Trout Brook. Facilities will be provided to allow the introduction of PAC to the SBRs, in the event that variations in ground water and LCG quality warrant supplemental PAC addition. Additionally, facilities will be provided to allow nitrogen and phosphorus additions in the event of nutrient deficiencies. Table 2-19 indicates the rationale for selection of each process.

Table 2-20 contains the preliminary flow and mass balance for the different unit processes proposed for the treatment of ground water and condensate at the Combe Fill South Landfill. This treatment strategy should be able to meet the heavy metals, VOC, BOD5 and all other effluent discharge limitations proposed for the treatment facility.

The mass balance contained in Table 2-20 and ultimately the preliminary design assumes the following:

TABLE 2-20

COMBE FILL SOUTH LANDFILL
SUPERFUND SITE REMEDIAL DESIGN
GW/CONDENSATE TREATMENT
PRELIMINARY BASIS OF DESIGN MASS BALANCE

	FLOW (gpd)	COD (lb/d)	BOD5 (lb/d)	NH3 (lb/d)	TSS (lb/d)	METALS (lb/d)
1	5000	160	80	2	0.5	0.008
2	170000	290	145	75	680	1.2
3	188000	290	145	75	830	1.2
4	184000	450	225	77	10	0.1
5	9000				1150	
6	182000	150	20	6	5	0.08
7	2300				50	
8	175000	120	18	5	2	0.07
9	7200				3	
10	175000	24	6	0.75	1	0.05
11	TBD					
12	365000**					
13	11300				1740	
14	18200				150	
15	****					

* - See next page for key to mass balance locations
** - lb GAC/yr; may range from 50000 to 500000 lb/yr, depending upon efficiency of upstream processes and whether PAC is used in central SBRs
*** - includes 0.5 lb $Ca(OH)_2$ per lb solids
**** - 90 cubic feet per day (7,200 lbs per day wet sludge)
TBD - to be determined

1) Ground water flow and gas condensate flow are projected to be 170,000 and 5,000 gpd, respectively.

2) Ground water strength is comparable to that reported in the RI

3) Landfill gas condensate quality is based on the one sample characterized.

4) Sludge generated from metals precipitation and SBRs will be thickened and subsequently processed through a filter press and disposed off-site.

5) The sludge pressure filter filtrate and sand filter backwash, and GAC backwash will be routed to the head of the plant.

6) Landfill gas condensate will be contained in an aerated equalization tank and combined with the ground water prior to treatment with SBRs.

2.12 Treatability Study References

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3. Lofy, Ronald J. "Landfill Gas Condensate and Its Disposal" presented at University of Wisconsin. Extension Course, Sanitary Landfill Gas and Leachate Management, 1985.

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5. Meidel, J.A. and R.L. Peterson. 1987. "The Treatment of Contaminated Ground Water and RCRA Wastewater at Bofors-Nobel, Inc." Fourth National RCRA Conference on Hazardous Waste and Hazardous Materials (HMCRI). Washington D.C.. March 16-18.

6. Meidel, J.A. and Vollstedt, T.J. 1986. "Use of Powdered Carbon to Treat Contaminated Ground Water and Leachate" Haz Tech International Conference, Denver, CO. August 13, 1986.

7. Ying, W., R. Bonk, and S. Sojka. 1987. "Treatment of Landfill Leachate in Powdered Activated Carbon Enhanced Sequencing Batch Bioreactors." Environmental Progress. February, 1987.

SECTION 3 - PRELIMINARY DESIGN

3.01 Design Criteria

Based upon the results of the laboratory treatability studies described in the previous section and based on accepted practices of environmental engineering design, a treatment system has been selected for treatment of ground water and condensate to be generated at the Combe Fill South Landfill. The treatment technology selected is a combination of physical, chemical and biological treatment designed to remove the identified constituents in the ground water and condensate. The selected technology dictates the required equipment such as treatment tankage, mixing devices, clarification units, filters, biological units and sludge dewatering equipment. The basis of design of the treatment system components was developed based on the process evaluations and testing performed, projected flow rates, and the established criteria for the treatment system.

This section of the report outlines the design criteria evaluated, the preliminary process description for the proposed treatment facilities and a brief review of the permitting requirements associated with ground water/condensate treatment.

In the process of developing the basis of design for the ground water treatment facility, several major considerations have been included in the system selection and engineering process. These considerations include:

- The variability in anticipated influent flow and loadings likely to be encountered over the life of the treatment facility.

- The high degree of system reliability required due to the nature of the project and the need to consistently meet discharge limitations under variable conditions.
- A design that will accommodate drastic reductions in flow over time.
- A facility that can reasonably be expected to operate successfully without full time around the clock operator attendance.
- A degree of built in redundancy and fail safe concepts that result in a high degree of reliability in a reasonably cost effective manner.

These considerations along, with data collected at the site, treatability testing results and engineering judgements, form the basis of the design concepts described herein. Specific basis of design criteria include the following major items.

<u>Flow</u>

The design flow for the ground water treatment facility is based on two flow sources: landfill gas condensate (LGC) and recovered shallow ground water. The volume of LGC is estimated to be approximately 6000 gpd (max.) based on literature values and as high as 5400 gpd based on thermodynamic properties. In light of the reported literature values and recognition that the exact conditions which will be present when the gas extraction system is put into operation are not well defined, a conservative design flow rate of 5000 gpd (max.) of LGC has been selected for the design basis.

The volume of ground water currently flowing out of the landfill is estimated to be approximately 170,000 gpd. Placement of the landfill cap and cover is expected to reduce this flow volume over time. The reduction is calculated to be approximately 50 percent within two years of cap and cover completion and 90 percent within 10 years.

Based on present estimates, the ground water recovery wells will be capable of pumping approximately 280,000 gpd at the time of installation.

The proposed construction schedule includes a 36 month duration of construction. The ground water collection and treatment system is scheduled to be completed at approximately the mid point of construction (month 18) and the landfill cap and cover be installed between month 15 & 36.

As the landfill cap and cover will be partially in place over the final 20 months of construction, it is estimated that the volume of ground water discharge from the landfill will be substantially reduced. Further reductions will occur if the ground water treatment plant is in operation during the last 18 months of the project. The combined effect serves to reduce the estimated ground water discharge volume to approximately 140,000 gpd. The selected design capacity of the ground water treatment plant is based on this daily volume plus a 20 percent reserve for a total average daily design capacity of 170,000 gpd. Adding the 5000 gpd estimated LGC volume results in a total design capacity of 175,000 gpd. The 20 percent reserve capacity is thought to be conservative to provide flexibility to accommodate actual field conditions once ground water pumping operations begin and quality and quantity characteristics are known.

Loadings

Organic and inorganic contaminants in the ground water were measured from shallow well samples within the landfill area and appear in Table 2-1. From the measured values, expected average influent characteristics were developed (Table 2-2). A single sample of LGC was obtained and contaminant levels analyzed (Table 2-6). Additionally, LGC characteristics were obtained from reported literature (Table 2-7). The combined ground water and LGC characteristics were used for the design basis of the ground water treatment facility. These loadings appear in Figure 3-3.

Treatment Processes

The recommendations of the treatability studies form the design basis for the proposed ground water treatment facility as outlined in Section 2.11. The recommended facility includes the following major unit processes:

- flow equalization (ground water)
- flow equalization (LGC)
- heavy metals removed via co-precipitation with ferric sulfate
- pH adjustment
- biological treatment
- filtration
- granular activated carbon (GAC) adsorption

As no source was identified locally to which liquid sludges could be shipped, it is recommended that on-site sludge dewatering be provided. Sludge handling for this project is proposed to include the following unit processes:

- aerated sludge holding tank(s) for biological sludges with provisions for decanting
- gravity sludge thickening for metal hydroxide sludge
- sludge conditioning with polymer, ferric chloride and lime
- sludge dewatering via recessed plate and frame filter press
- shipment off-site of dewatered sludge cake for disposal.

3.02 Process Description/Basis of Design

The purpose of this section is to describe the unit processes which are proposed to constitute the ground water/LGC treatment system. A description of the process flow scheme is provided as well as the major design parameters of the various treatment system components. Figure 3-1 presents the process flow diagram for the proposed treatment facility, Figure 3-2 contains the process and instrumentation diagram and Figure 3-3 presents a mass balance of the process. Figure 3-4 provides a site layout depicting the orientation of the ground water treatment facility. Table 3-1 provides equipment descriptions and preliminary sizing criteria.

A description and narrative discussion is provided herein for each major unit process.

Flow Equalization

Flow equalization is proposed to accomplish the following five functions:

1) dampen hydraulic effects on downstream process systems resulting from flow volume variations,
2) provide short term emergency storage,

TABLE 3-1

COMBE FILL SOUTH LANDFILL

GROUND WATER TREATMENT FACILITY

MAJOR PROCESS EQUIPMENT BASIS OF DESIGN

Process Equipment Designation	Equipment Description	Equipment Sizing Criteria
Ground Water Flow Equalization Tank T-101	Circular above grade, open top, welded steel tank, aerated 87,500 gal.	12 hrs. detention @ design flow rate (175,000 gpd) with 2' freeboard, 34' dia., 15' high, aerated to mix NAOH & suspend solids
LGC Equalization Tank T-102	Circular above grade, open top welded steel tank aerated, 25,000 gal.	5 days detention @ 5,000 gpd (max. with 2' freeboard, 18' dia. x 15' high
Ground Water Equalization Pumps P-101 A/B	(2) horizontal centrifugal, 120 gpm, 2-1/2 hp, variable speed (100% standby)	Peak design flow rate = 170,000 gpd ÷ 1440 min/day = 120 gpm + 15% reserve = 140 gpm (max. capacity each pump)
Condensate Equalization Pumps P-102 A/B	(2) horizontal centrifugal, 10 gpm (max) 1/2 hp, variable speed (100% standby)	Peak design condensate flow = 5000 gpd ÷ 1440 min/day = 3.5 gpm
Metals Removal System M-101	(1) Skid mounted package with inclined plate settler with rapid mix tank (100 gal) flocculation tank (500 gal) gravity sludge thickener (2,000 gal) with scraper mechanism	1 min. rapid mix tank detection @ 120 gpm = 120 gal 5 min. flocculation tank detention @ 120 gpm = 600 gal 0.3 - 0.6 gpm/sf clarifier loading, @ 170,000 gpd with 300 sf inclined, settler, loading rate = 0.40 gpm/sf call (all criteria based on vendor recommendation)
Sodium Hydroxide (NaOH) Feed System T-103, P-109 A/B	4,500 gal FRP storage tank, 8' dia. x 12' high (2) diaphragm metering pumps 5 gph max. rate, variable speed, pH control	With 50% NaOH sol, 0.55 gal. NaOH required/1,000 gal $0.55 \times \frac{175{,}000}{1{,}000}$ = 100 gal. NaOH/day Provide 45 day storage capacity = 4,500 gal. tank Meter pump rate 100 gpd ÷ 24 hrs/day = 4.2 gph

TABLE 3-1 (Continued)

Process Equipment Designation	Equipment Description	Equipment Sizing Criteria
Ferric Sulfate Feed System T-107, P-109 A/B	500 gal. solution batch mix tank, FRP with bag breaker feeder, (2) diaphragm metering pumps 20 gphr max. rate, variable speed, flow proportional	Dose 100 mg/l as Fe (treatability report) Fe required = .175 MGD x 8.34 x 100 mg/L = 145 lbs/day Ferrifloc, 70 lb/CF, 18.5% Fe = 13 lb Fe/CF 11 CF/day @ 70 lbs/CF = 780 lb Ferricfloc/day Batch @ 2 lbs. Ferrifloc/gal = 400 gal batch/day Pump max. rate 400 gpd + 24 hrs/day = 16.7 gph
Polymer Feed System P-110 A/B	Modular emulsion/dry feed polymer batch unit with feed, mix tank, metering pump and controls	Dose 0.25 mg/l (treatability report) use 0.5 mg/l Feed rate 0.5 mg/l = .175 mgd x 8.34 x 0.5 mg/l = 0.7 lb/day
Sequencing Batch Reactors Q-101A/B	(2) Modular, above grade steel tank with 4 internal compartments: - influent holding - SBR reactor - decant holding - sludge holding	2 SBR units nominal rated @ 87,500 gpd each operating @ 2 - 12 hour cycles (from treatability report) Influent holding tank - 12 hours detention with 20% reserve @ 87,500 gpd = 43,750 gal + 20% = 52,500 gal capacity Reactor tank, 200 lbs BOD + 0.1 lb BOD/lb MLSS = 2000 lb MLSS 2000 lbs MLSS + (2500 mg/L x 8.34) = 0.095 MGal, say 100,000 gal + 2 tanks = 50,000 gal capacity/tank Decant holding tank, 12 hours detention = 43,750 gal Sludge holding tank, 2,300 gpd waste sludge with 15 days detention = 35,000 gal
SBR Feed Pumps P-103 A/B	(3) Submersible (uninstalled spare) 750 gpm, 5 hp, variable speed drive	SBR feed rate, 43,750 gal in 1 hour (treatability report) 43,750 gal/60 min. = 730 gpm max. rate each pump
SBR Aeration Blowers B-101 A/B/C	(3) Positive displacement, 15 hp, 280 scfm @ 7.5 psi (50% standby)	200 lbs BOD/day x 2000 CF air/lb = 380,000 CF air + 1440 min/day = 280 scfm
Filter Feed Pumps P-106-A/B	(2) Submersible (uninstalled spare) 120 gpm 2.5 hp, variable speed drive	Peak flow = 175,000 gpd + 1,440 min/day = 120 gpm + 15% reserve = 140 gpm (max. capacity each pump)

TABLE 3-1 (Continued)

Process Equipment Designation	Equipment Description	Equipment Sizing Criteria
Sand Filter SF-101 A/B	(2) Continuous backwash, upflow, deep bad granular media, 5' dia. x 12'-6" high, 19 sf filtration area	4-8 gpm/sf loading rate @ 100 mg/l TSS (max) (vendor recommendation) Loading rate with two filters in operation = 120 gpm + (19 sf/filter x 2 filter) = 3.2 gpm/sf Loading rate with one filter in operation = 120 gpm + 19 sf/filter = 6.3 gpm/sf
Filtrate Holding Tank T-104	(1) Circular, flat bottom, open top FRP, 1,800 gal, 6' dia x 9' high	15 min. detention @ 120 gpm = 1,800 gal
Filtrate Pumps P-104 A/B	(2) Horizontal centrifugal 140 gpm, 5 hp, variable speed drive	Peak flow = 175,000 + 1440 = 120 gpm + 15% reserve = 140 gpm
Carbon Adsorption Units C-101 A/B	(2) 20,000 lb carbon capacity carbon vessels, skid mounted, pre-piped, down flow, fixed with 20,000 # spent carbon transfer tank (10' dia.)	Sized for 20,000 truck load delivery
Effluent Monitoring Tank T-105	(1) Circular, flat bottom, open top, FRP 600 gal, 4' dia. x 7'-0" high	5 min. detention @ 120 gpm = 600 gal
Sludge Conditioning Tank T-106	(1) Circular, flat bottom, open top, FRP, 6500 gal, 10' dia x 10' high	Sized for one filter press batch, see filter press
Filter Press Feed Pumps P-105 A/B	(2) Air operated diaphragm 30 gpm	5500 gal\press cycle, 3 hour cycle, 5500 gal 180 min = 30 gpm

TABLE 3-1 (Continued)

Process Equipment Designation	Equipment Description	Equipment Sizing Criteria
Plate & Frame Filter Press F-101	(1) Recessed plate & frame with 35 cf press volume, 40" x 40" plates	1750 lbs. dry solid/day @ 1.8% solids, 11,700 gpd x 7/5 = 16,400 gpd (5 days/wk) Filter press vol. (ft^3) = $\frac{\text{gal/cycle} \times \%\ \text{sludge conc.} \times 8.34 \times 5.6}{\text{cake density (lbs/CF)} \times \text{cake \% solids}}$ = $\frac{5{,}500\ \text{gal} \times 0.018 \times 8.34 \times 1.07}{80\ \text{lbs/CF} \times 0.30}$ = 37 CF (assume three cycles/day)
Phosphoric Acid (Nutrient) Feed Pump P-113	(1) Metering pump from 55 gal drum, variable speed, flow proportional	to be determined in final design
Ammonium Hydroxide (nutrient) Feed Pump P-112	(1) Metering pump from 55 gal. drum, variable speed, pH controller	to be determined in final design
Sulfuric Acid Feed (pH adjust) Feed Pump P-111	(1) Metering pump from 55 gal. drum, variable speed, pH controller	to be determined in final design

3) dampen loading effects on downstream process system resulting from loading variations,

4) allow for one shift operation of the treatment facility as flows reduce over time, and

5) provide mixing of ground water with sodium hydroxide for pH adjustment prior to the metals removal step.

The proposed layout includes two above grade circular steel equalization tanks with a capacity of approximately 87,500 gallons and 25,000 gallons for ground water and LGC, respectively. The tanks would be provided with a diffused aeration system to provide mixing and to suspend solids. A 87,500 gallon volume was selected for the ground water flow equalization tank so that the ground water treatment facility could operate on the day shift only, seven days per week at approximately year four and operate day shift, 5 days per week at approximately year six based on flow projections over time.

Both flow equalization tanks would be provided with air diffusers to provide mixing, suspend solids, strip volatiles and prevent septicity of organic compounds. The ground water flow equalization tank will serve as a pH adjustment tank to facilitate the downstream metals removal step. Sodium hydroxide and ferric sulfate solutions will be metered into the ground water flow equalization tank on a pH controlled and flow proportional basis, respectively.

The effluent of the LGC flow equalization tank will be pumped by a variable speed, setpoint controlled pump to a point upstream of the SBRs. The ground water flow equalization tank effluent will be pumped by a variable speed, setpoint controlled pump to the downstream metals removal process. Both pumps will be provided with 100 percent standby capacity.

Both tanks will be fitted with level indicators, high level alarms, overflows from one tank to the other and tank fittings to allow pump out to a tanker truck.

Metals Removal

Based on the treatability testing results and recommendations in Section 2.06, chemical co-precipitation and clarification is proposed upstream of biological treatment. Metals removal via metal hydroxide precipitation with ferric sulfate aided by polyelectrolyte was demonstrated to meet objectives in the treatability evaluation.

The system proposed for this project consists of a skid mounted inclined plate settler unit with integral rapid mixing tank and flocculation tank. Additionally, an integrally mounted sludge thickener is provided beneath the inclined plate settler unit. Systems of this type are commonly applied for this purpose and are used extensively in industry.

As flow equalization is provided upstream, a continuous flow through unit is proposed and is available as a packaged unit in the desired size range. Clarification by inclined plate vs. traditional gravity clarifiers has proved successful for metal hydroxide sludges and is preferred since less space is required for the clarification unit and the system requires less mechanical components. The proposed metals removal unit contains no moving parts other than a simple mixer and flocculator, thus it is felt that maintenance requirements will be minimal and redundancy will not be necessary. Packaged inclined plate settler units are available with an integral sludge thickener tank mounted beneath the settler tank. This feature is proposed to eliminate the need for piping sludge to a remote tank and, therefore, reducing operational labor.

The sizing of the rapid mix/flocculation/inclined plate settler unit is based on the hydraulic flow rate. A typical loading rate for a metal hydroxide sludge is 0.3 to 0.6 gpm/sf based on a unit with inclined plates set at a 55° angle to the horizontal and the surface area based on 80 percent of the projected horizontal surface area. For this project, a 300 sf projected surface area unit is proposed, which at an initial design flow of 188,000 gpd (design flow and recycle streams) would provide a loading rate of 0.43 gpm/sf. The integral rapid mix and flocculation tanks are provided with 1 minute (120 gal) and 5 minutes detention time (600 gal).

The integral sludge thickener is mounted beneath the inclined plate settler and is provided with a mechanical sludge scraper mechanism. This arrangement allows solids which settle in the inclined plate settler to pass directly to the thickener tank. The thickener provides the function of reducing the sludge volume by increasing the percent solids and provides for storage of sludge solids between operation of the sludge dewatering system.

Equipment ancillary to the inclined plate settler will include a feed systems for sodium hydroxide, ferric sulfate and polymer and thickened sludge pumps.

Biological Treatment

The organic strength of the ground water has been characterized as shown in Table 2-2 This loading, combined with the loading of the LGC, forms the design organic loading of the biological treatment pro- process.

Biological treatability testing was conducted utilizing a sequencing batch reactor (SBR) process. The SBR process can be described as a fill and draw, cyclic batch treatment type activated sludge process in which the SBR tank is filled with wastewater during a selected time period followed by selected time periods of aeration, settling, decanting and idle after which the cycle is repeated. This cyclic process coupled with a programmable logic controller provides an extremely flexible system which is not possible in a continuous flow biological process. By varying the operating strategy, aerobic, anaerobic, or anoxic conditions may be achieved allowing for development of desirable microorganisms while the growth of undesirable microorganisms is inhibited. This operating flexibility is well suited to the ground water flow and loading variations likely to be encountered on this project. Additionally, the treatability testing was conducted utilizing a SBRs.

Physically, the biological treatment process for this project is proposed to include two SBR tanks each with a nominal design capacity of 75,000 gpd. Each SBR tank is proposed to be a circular above grade steel tank with four internal compartments (Figure 3-5). The internal compartments would include: influent holding tank, SBR reactor tank, decant holding tank and sludge holding tank. All tanks would be aerated with diffused air. The influent holding tank is provided to retain influent flows between SBR cycles and the decant holding tank is provided to equalize decant flows prior to filtration. Other major components of the system will include:

- SBR feed pumps to transfer wastewater from the influent holding compartment to the SBR reactor.
- Diffused aeration system for mixing and aerating all four compartments.
- SBR decanter mechanism.
- Aeration blowers.
- Powered Activated Carbon (PAC) addition system.
- Sludge wasting pump.
- Nutrient feed system including storage tank and flow proportional metering pumps for phosphoric acid and ammonium hydroxide.
- programmable logic controller.

Two SBR tanks are proposed which, at start-up, would be nominally capable of processing 50 percent of the design flow (75,000 gpd ea.). After approximately two years of operation, when average daily flows are projected to have decreased to approximately 75,000 gpd, 100% standby redundancy of the SBR tanks would exist and in the normal operation mode, only one SBR tank would be in service.

An F/M ratio of approximately 0.1 lbs BOD/lb MLVSS is recommended for the full-scale treatment system and is typical of extended aeration treatment processes. At an F/M ratio of 0.1, microorganisms will operate in the endogenous respiration mode. This will limit the quantity of biological sludge requiring dewatering and disposal.

As discussed in Section 2.11, powered activated carbon (PAC) addition to the SBR reactor is recommended. Physical facilities to add PAC, will be included in the design of the biological treatment system and would include room for PAC containter storage and carbon slurry feed, piping, eductor and valves. A royalty must be paid to a private licensor when the PAC system is placed into service.

Filtration

To consistently meet the objectives of effluent suspended solids and to prevent blinding of the downstream carbon adsorption units, filtration of biological treatment process effluent is proposed. Two 5-foot diameter x 12'-6" high upflow sand filters are proposed. This type of pressure filtration unit is recommended due to the continuous nature of operation.

Traditional filters (either gravity or pressure) are taken out of service for backwashing for removal of solids from the filter media. The water necessary for backwash and the resultant backwash waste require inclusion of holding tanks along with pumps, automated valves and controls. The continuous backwash filter requires only the filter units and a compressed air source for operation.

This type of filter has been successfully applied in numerous industrial waste treatment applications, both in biological waste treatment systems and physical/chemical treatment systems.

Application rates for the filters are approximately 4-8 gpm/SF for biological solids with loadings up to 20 mg/L. A 19 SF filter is proposed with a 100% standby unit. With one filter in operation at a design flow rate of 120 gpm (175,000 gpd), the loading rate is 6.3 gpm/SF.

Equipment ancillary to the sand filters include an air compressor and a filter feed pump. The filter contains no moving parts and generally requires little operator attention or maintenance.

Carbon Adsorption

Consistent and high level removals of trace organics to a level consistent with discharge objectives requires polishing by carbon adsorption. Carbon adsorption should act as a failsafe system to prevent discharge of organics should the upstream biological treatment units experience an upset.

A dual module, skid mounted, package carbon adsorption unit is proposed. The unit is pre-piped to allow for flow through the vessels in series or parallel modes of operation. It would include two (2) 10 ft diameter carbon steel vessels each holding 20,000 pounds of carbon. As a delivery truck load of carbon is 20,000 pounds, this vessel sizing is proposed to maximize the economics of bulk carbon purchases. At a flow rate of 100 gpm, each adsorber provides approximately 50 minutes of contact time.

Equipment ancillary to the carbon adsorber units include a carbon transfer tank and compressed air source is necessary for carbon transfer during changeout.

Effluent Monitoring Tank

Effluent from the carbon adsorber units is proposed to discharge to a 600 gallon FRP tank within the ground water treatment process building. The tank would serve as an effluent monitoring tank from which a composite sample would be drawn.

Sludge Handling System

The sludge handling system includes the following major items of equipment:

- (2) 35,000 gallon capacity aerated biological sludge holding tanks with decant mechanisms. This volume provides approximately fifteen days retention at design conditions and will enable reductions of the volatile organics fraction of the sludge solids and will provide system storage.
- (1) 2000 gallon capacity gravity sludge thickener mounted beneath the inclined plate settler. The unit includes a mechanical scraper type sludge collector.
- (1) sludge conditioning tank to blend sludge with conditioning chemicals.
- chemical feed systems for sludge conditioning prior to dewatering including provisions to feed polymer, ferric chloride and lime slurry.
- (1) plate and frame pressure filter with approximately 37 cf press volume.
- (2) air operated high pressure filter feed pumps.

The sludge dewatering system will likely require three filter press cycles per day, five days per week when the facility is placed into service based on the expected design loadings. The filter press is expected to operate on a 4 hour cycle (approximately) and will discharge dewatered sludge cake into a container suitable for discharge to a sludge hauling vehicle.

3.03 Site and Ancillary Systems Description

Site Plan

The ground water treatment facility is proposed to be located adjacent to the gas extraction building as shown on Figure 3-4. This location is within the site property lines, outside the known limits of refuse, above the 100 year flood level and not located in wetlands. Additionally, the proposed site is convenient to the proposed access road, utility entrance locations and provides easy routing for the effluent sewer

As the proposed structures are approximately 900 feet from the public road and 800 feet from the nearest residence and the view of the proposed structures will be obstructed by trees, visual impact will be limited.

The layout of the proposed structures, tanks, and equipment is arranged in a plan to provide optimal use of floor space, minimum land requirements and easy access for operator attention. The proposed layout (Figure 3-5) provides for four exterior tanks:

T - 101 Ground Water Flow Equipment Tank

T - 102 LGC Flow Equalization Tank

Q - 101A/B Sequencing Batch Reactor Tanks (2)

Process Equipment Building

A process equipment building is proposed to be located adjacent to the tanks and would house the following major components and systems:

- metals removal system
- upflow sand filters
- carbon adsorption units
- intermediate process tanks
- process pumps
- chemical storage and feed equipment
- process blowers
- sludge filter press

Additionally, floor space will be allocated in the final design for the following:

- power distribution and control
- storage of chemicals
- plant control room
- office space
- lavatory/shower/locker room
- miscellaneous storage

The process equipment building is proposed to be a pre-engineered steel framed structure with aluminum siding and roofing panels matching the adjacent gas extraction building.

According to the New Jersey Uniform Building Code, which references the BOCA National Building Code, this structure will be classified as "use group F and H" (Section 3.06.1 of BOCA).

Process Control and Instrumentation

The level of process control and instrumentation systems will include sufficient hardware to monitor system performance and control certain elements of the process. A process and instrumentation diagram is shown in Figure 3-2 which indicates the major instrumentation devices for the system.

The design basis for the instrumentation and control system will include sufficient control devices so that unattended second shift and third shift is possible.

The instrumentation and control system will be provided to include a highly reliable operating system due to the incorporation of critical alarms, system status monitoring and key system controls.

Outfall

A gravity outfall pipeline to convey treated effluent is proposed to extend from the south end of the process equipment building in a westerly direction passing beneath the plant entrance road to a headwall west of the entrance road (see Figure 3-4). A stone lined ditch is proposed to carry the effluent to the upper reach of Trout Brook. An elevation differential of approximately 15 feet is available between the location of the headwall and the discharge point. The aeration effect of the flow over the stone lined ditch will be sufficient to provide necessary effluent dissolved oxygen level.

3.04 Permitting

The permits which will be required relative to the proposed treatment facilities were discussed at length in the preliminary design report previously submitted in July 1989. An NJDEP permit will be required for the discharge to Trout Brook. In addition, wet lands permits, local building permits, air quality permits and sediment control certification may be required. The specific requirements and application procedures relative to these permits have been discussed in the previous draft report with the exception of air permits and well drilling permits, which are discussed below.

With regard to air emissions, neither the equalization tanks nor the ground water SBRs should require emissions controls for volatile organic compounds. The sum of maximum concentrations of volatile organic compounds found in the different ground water monitoring wells is 534 ug/L (see Table 2-1). For the design flow of 140,000 gallons per day and assuming that all VOCs volatilized from the system, the total VOC emissions would be approximately 0.6 pound per day. New Jersey regulations (N.J.A.C. 7:27-17) indicate that an air permit is not necessary for waste and water treatment equipment if the total concentration of volatile organic substances (VOS) does not exceed 3,500 ug/l and if each of the VOSs included in N.J.A.C. 7:27-17 does not exceed 100 ug/l. The listed compounds found in ground water at CFSL are below the 100 ug/l limit for permit requirements. Dependent on condensate quality, emission controls may be necessary for the condensate pretreatment system.

An exception to the N.J.A.C. 7:27-17 exemption for waste and water treatment equipment is air stripping equipment with capacities greater than 100,000 gpd. The definition of "air stripping equipment," provided in NJAC 7:27-8.1, means equipment used to transfer volatile organic substances from water into the atmosphere. Specific examples presented within the definition include packed columns and water spray equipment. Therefore, the exception for "air stripping equipment with a capacity greater than 100,000 gallons per day" (NJAC

7:27-8.2(a)15.ii) would not apply to the proposed treatment facility. For this reason, an air permit is not required for the facility.

The NJDEP Bureau of Water Allocation requires the completion of drilling permits for all wells or borings which encounter ground water prior to the commencement of drilling. Well permit are as requirements specified in NJAC 7:14A-6.13. Permit applications are typically completed by the drilling company and signed by the party with overall responsibility for the well or boring.

3.05 Summary

In summary, the treatability testing evaluation has indicated that a combination of influent holding, metals removal, biological treatment, filtration and carbon adsorption are required to meet the stated effluent requirements based on projected influent constituents. This report has presented a preliminary basis of design of the treatment processes which are anticipated to achieve the stated objectives. Information is included in the report entitled "Final Design Combe Fill South Landfill Superfund Site Remedial Construction" relative to the estimated construction costs of the proposed facilities as well as the construction sequencing plan and the anticipated implementation schedule. Further design development will be conducted during the final detailed design phase of this program which will ultimately result in the issuing of detailed design plans and specifications to allow bidding of the facility's construction.

Appendices

O'BRIEN & GERE

APPENDIX 1

TEST CONDITIONS - ACUTE TOXICITY TEST

REPORT FORM 1. RECORD OF CONFORMANCE WITH TEST CONDITIONS:
DAPHNIA MAGNA ACUTE TOXICITY TEST.

Laboratory: OBG
Location: Syracuse, NY
Test Dates: 7/31/89-8/4/89
Analyst: Bill Hesse

TEST CONDITION	RECOMMENDED	ACTUAL
1. Temperature:	22 ± 2C	Max 25.5 Min 24
2. Light intensity:	50-100 ft-c	Max 200 Min 80 Mean 125 N 6
3. Photoperiod:	16L/8D	16L/8D
4. Test chamber size:	Greater than 1 L	470 ml
5. Test solution volume:	1 L	350 ml
6. Renewal of test solutions:	Daily renewal	Y (Y/N)
7. Age of test organisms:	0 - 5 days	48-H
8. Range in age:	24-h	24-H
9. No. organisms/test chamber:	10	10
10. No. replicate test chambers/concentration:	2	2
11. Feeding regime:	Fed ad lititum prior to and during the test	N (Y/N)
12. Aeration:	None, unless DO falls below 40% saturation. Rate should not exceed 100 bubbles/min.	N (Y/N) Rate
13. Dilution water:	Trout Brook	(ppt)
14. Laboratory pure water:	Laboratory pure water used to prepare synthetic dilution water	N/A (Y/N)
15. Dilution series:	0.5	0.5
16. Test acceptability:	Greater than 85% survival in controls	N (Y/N)

REPORT FORM 3. SURVIVAL DATA FROM DAPHNIA 96-HOUR DAILY-RENEWAL, ACUTE TOXICITY TEST.

Laboratory: O'Brien & Gere Engineers, Inc. Test Dates: 7/31/89 - 8/4/89
Location: Syracuse, NY Analyst: Bill Hesse

Conc:	Rep:	START	24H	48H	72H	96H
		No. Live Organisms				
Control 0%	A:	10	10	10	0	0
Control 0%	B:	10	10	10	0	0
6.25 %	A:	10	10	10	1	0
6.25 %	B:	10	10	10	1	0
12.5 %	A:	10	10	10	8	0
12.5 %	B:	10	10	10	9	0
25 %	A:	10	10	10	10	10
25 %	B:	10	9	9	9	9
50 %	A:	10	9	9	9	9
50 %	B:	10	9	9	9	9
100 %	A:	10	8	8	8	8
100 %	B:	10	10	9	9	9

REPORT FORM 1. RECORD OF CONFORMANCE WITH TEST CONDITIONS: FATHEAD MINNOW (PIMEPHALES PROMELAS) ACUTE TOXICITY TEST.

Laboratory: OBG
Location: Syracuse, NY
Test Dates: 7/19/89-7/23/89
Analyst: Bill Hesse

TEST CONDITION	RECOMMENDED	ACTUAL
1. Temperature:	22 ± 2C	Max 25.5 Min 24
2. Light intensity:	50-100 ft-c	Max 200 Min 80 Mean 125 N 6
3. Photoperiod:	16L/8D	166/80
4. Test chamber size:	1 L	470 ml
5. Test solution volume:	500 mL	350 ml
6. Renewal of test solutions:	Daily renewal	Y (Y/N)
7. Age of test organisms (Days):	14-30 days	20
8. Range in age (Hours):	48-h	24-h
9. Loading:	Not to exceed 0.4 g wet wgt/L	<0.4g
10. No. organisms/test chamber:	10	10
11. No. replicate test chambers/concentration:	2	2
12. Feeding regime:	Not fed 24 h prior to or during the test	Y (Y/N)
13. Aeration:	None, unless DO falls below 40% saturation. Rate should not exceed 100 bubbles/min.	N (Y/N) Rate
14. Dilution water:	Trout Brook	410 (Hard) 694 (Alk)
15. Laboratory pure water:	Laboratory pure water used to prepare synthetic dilution water.	N/A (Y/N)

REPORT FORM 1. RECORD OF CONFORMANCE WITH TEST CONDITIONS: FATHEAD MINNOW (PIMEPHALES PROMELAS) ACUTE TOXICITY TEST (CONTINUED)

Laboratory: OBG Test Dates: 7/19/89-7/23/89
Location: Syracuse, NY Analyst: Bill Hesse

TEST CONDITION	RECOMMENDED	ACTUAL
16. Dilution series:	0.5	0.5
17. Test acceptability:	Greater than 90% survival in controls	N (Y/N)

REPORT FORM 3. SURVIVAL, LENGTH, AND WEIGHT DATA FROM FATHEAD MINNOW 96-HOUR, DAILY-RENEWAL, ACUTE TOXICITY TEST

Laboratory: O'Brien & Gere Engineers, Inc. Test Dates: 7/19/89-7/23/89
Location: Syracuse, NY 13221 Analyst: Bill Hesse

		No. Live Organisms				
Conc:	Rep:	START	24H	48H	72H	96H
Control 0%	A:	10	10	10	9	9
Control 0%	B:	10	10	8	8	7
6.25%	A:	10	10	10	10	10
6.25%	B:	10	10	10	9	8
12.5%	A:	10	10	10	10	10
12.5%	B:	10	9	8	7	5
25%	A:	10	10	10	10	6
25%	B:	10	10	10	10	9
50%	A:	10	9	9	9	8
50%	B:	10	10	9	9	7
100%	A:	10	10	10	10	9
100%	B:	10	10	10	10	8

Organism Length (mm) Organism Wet Weight (mg)

MEAN = ______ ± ______ MEAN = ______ ± ______

REPORT FORM 4. PHYSICAL AND CHEMICAL DATA FROM FATHEAD MINNOW & DAPHNIA ACUTE TOXICITY TEST.

Laboratory: O'Brien & Gere Engineers, Inc. Test Dates: 7/31/89 - 8/4/89
Location: Syracuse, NY Analyst: Bill Hesse

Control: 0	Day 1	Day 3	Day 5	
Temp: Initial	25	24	25.2	
Final	-	-	-	
D.O. Initial	6.3	9.5	6.8	
Final	-	-	-	
pH Initial	7.5	8.2	7.9	
Final	-	-	-	
Cond: Initial	269	579	284	
Final	-	-	-	
Alkalinity	100	-	59.8	
Hardness	171	239.4	171	

Conc: 6.25	Day 1	Day 3	Day 5	
Temp: Initial	22.4	25	25.2	
Final	-	-	-	
D.O. Initial	6.7	9.0	7.2	
Final	-	-	-	
pH Initial	8.0	8.2	8.2	
Final	-	-	-	
Cond: Initial	372	529	617	
Final	-	-	-	
Alkalinity	104	132	119.7	
Hardness	188	239.4	183.3	

Conc: 12.5	Day 1	Day 3	Day 5	
Temp: Initial	22.6	-	25.2	
Final	-	-	-	
D.O. Initial	8.2	-	7.6	
Final	-	-	-	
pH Initial	7.8	-	8.1	
Final	-	-	-	
Cond: Initial	356	-	734	
Final	-	-	-	
Alkalinity	62	-	133.4	
Hardness	102.6	-	239.4	

REPORT FORM 4. PHYSICAL AND CHEMICAL DATA FROM FATHEAD MINNOW & DAPHNIA ACUTE TOXICITY TEST (CONTINUED)

Laboratory: O'Brien & Gere Engineers Test Dates: 7/31/89 - 8/4/89
Location: Syracuse, NY Analyst: Bill Hesse

Conc: 25		Day		
	1	3	5	
Temp: Initial	22.8	25	25.2	
Final	-	-	-	
D.O. Initial	8.1	8.2	6.8	
Final	-	-	-	
pH Initial	8.3	8.2	8.4	
Final	-	-	-	
Cond: Initial	819	978	1045	
Final	-	-	-	
Alkalinity	134	364	232	
Hardness	205.2	239.4	273.6	

Conc: 100		Day		
	1	3	5	
Temp: Initial	23.3	25.5	25.2	
Final	-	-	-	
D.O. Initial	6.7	6.3	6.7	
Final	-	-	-	
pH Initial	8.0	8.9	8.8	
Final	-	-	-	
Cond: Initial	72,000	1,000	1,000	
Final	-	-	-	
Alkalinity	279	694	486	
Hardness	428	478.8	427.5	

Conc:		Day		
	1	2	3	4
Temp: Initial				
Final				
D.O. Initial				
Final				
pH Initial				
Final				
Cond: Initial				
Final				
Alkalinity				
Hardness				

Exhibits

O'BRIEN & GERE

EXHIBIT A

CHRONIC TOXICITY TEST RESULTS

INTERNATIONAL TECHNOLOGY CORPORATION

RECEIVED
OCT 11 1989
O'B & G
EDISON

Combe Fill South
3013.012
cc: AJC

October 10, 1989

Mr. Daniel R. Kopcow
O'Brien & Gere Engineers, Inc.
Raritan Plaza 1
Edison, NJ 08837

Dear Mr. Kopcow

Enclosed are multiple copies of results and methodologies from chronic toxicity tests conducted from September 20 to September 28, 1989. Two organisms were exposed to the treatability test effluent, namely the fathead minnow, Pimephales promelas and the water flea, Ceriodaphnia dubia.

For the Fathead test, survival was determined to be the most sensitive end point with an LC50 of 92.9%, an NOEC of 50 %, an LOEC of 100% and a Chronic Value of 70.7%.

For the Ceriodaphnid test, reproduction was determined to be the most sensitive end point with an NOEC of 50%, an LOEC of 100% and a Chronic Value of 70.7%.

If you have any furthur questions, please do not hesitate to call either of us at (201) 225-2000.

Sincerely Yours

IT Corporation

David J. Kent
Manager
Biomonitoring Laboratory

Daniel J. Duh
Supervisor
Biomonitoring Laboratory

CHRONIC TOXICITY TESTS
CONDUCTED FOR
O'BRIEN & GERE ENGINEERS, INC.

SUBMITTED TO:

O'BRIEN & GERE ENGINEERS, INC.

SUBMITTED BY:

IT CORPORATION
165 FIELDCREST AVENUE
EDISON, NEW JERSEY 08818

OCTOBER 10, 1989

PROJECT # 572135

INTRODUCTION

O'Brien and Gere Engineers, Inc. contracted IT Corporation to conduct a pair of aquatic toxicity tests to determine chronic responses (survival, growth and reproduction) of two freshwater organisms, namely the fathead minnow (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*), to their treatability test effluent.

Both toxicity tests were conducted at the Biomonitoring laboratory of IT Corporation at Edison. The fathead test was conducted from September 20 to September 27, whereas the Ceriodaphnid test was conducted from September 20 to September 28, 1989.

SAMPLE COLLECTION AND HANDLING

The treatability test effluent was collected by O'Brien & Gere personnel on September 11, 1989 and brought to IT Corporation on September 15, 1989. The effluent was held in 1 gallon polypropylene containers and stored at 4 degrees C when not in use. Dilution water was collected on the 1st and 10th of September by IT personnel.

METHODS AND MATERIALS

All test species were reared at IT Corporation in accordance with EPA aquaculture guidelines. The advantage of "in-house" culturing is the ability to document the organism's health and development until proper test age is attained. Also, variability between tests is significantly reduced when using organisms with a "known" life history.

Daphnid species are cultured in Round Valley Reservoir (located near Lebanon, New Jersey) water which is also the test diluent for chronic testing. Weekly rearing procedures include two water renewals and periodic cropping to maintain a working culture density of 40 Ceriodaphnids per liter of holding water.

Minnows used for toxicity testing are cultured at IT in accordance with the EPA publication, "Guidelines for the culture of Fathead Minnows (*Pimephales promelas*) for use in Toxicity Tests," 1987. For chronic testing, fathead minnow fry less than 24 hour olds were used. These were obtained by allowing fertilized eggs to hatch from a PVC substrate in the dilution water. Egg fungus was not present during hatching. Fathead minnows are also cultured in Round Valley Reservoir water.

TEST DESIGN

Ceriodaphnid Chronic Test

For this test young C. dubia (< 24 hour old at test initiation) were continously exposed for 8 days under static renewal conditions to a dilution water control and five nominal concentrations of the effluent (100, 50, 25, 12.5, 6.25 percent effluent). Round Valley Reservoir water was used as the dilution and control water. Ceriodaphnids were individually placed in 30 ml plastic cups containing 15 ml of test solution or control water with 10 replicates per concentration (10 animals total per concentration). Test animals were fed daily with pre-measured doses of the algae Selenastrum capricornutum.

Test beakers were placed in a water bath system under specified test conditions (Temperature -- 25 +/-1 C; Photoperiod -- 16 hours light and 8 hours darkness, with a 30 minute phase in and phase out period; Light Intensity -- 50 to 100 fc). Surviving daphnids were transferred daily with a large bore pipette to newly prepared test solutions and fed. Temperature, Dissolved Oxygen, pH, Alkalinity, Hardness, and Conductivity were measured daily on composite samples of newly prepared concentrations. Parameters were run on control, low, medium and the highest concentrations every day. Dissolved Oxygen and pH were also measured on the 24 hour old solutions of the control, low, medium and high concentrations.

Observations on the number of live and dead (or immobilized) animals were made daily after transfer of the parent organism to fresh test solutions. Reproduction was monitored by enumerating the offspring per parent daily.

Fathead Chronic Test

Fathead minnows (<24 hours old) underwent a seven day experimental period under the same temperature and test concentrations as those employed during the daphnid testing. The minnows were exposed in groups of ten animals per 500 ml of test solution or control water with three replicate beakers per concentration (30 animals per concentration). Test chambers consisted of 600 ml polypropylene beakers filled with a total test volume of 500 ml. Following daily survival observations, the 24-hour old test solutions were slowly siphoned from the test chambers and then replaced with newly prepared test solutions.

Temperature, Dissolved Oxygen, pH, and Conductivity were measured daily on composite samples of newly prepared concentrations. Parameters were run on control, low, medium and the highest concentrations every day. Dissolved Oxygen and pH were also measured on the 24 hour old solutions of the control, low, medium and the highest concentration. Alkalinity and Hardness were measured on the control and the effluent on the first day. Observations on the number of live and dead animals were made daily until test completion.

Following termination of the test, all live fry within each replicate were rinsed with de-ionized water and placed in pre-weighed aluminum boats to be dried in an oven (VWR-Model) for 16 hours. After drying they were weighed as a group and the total dry fry weight per replicate was then divided by the total number of fry weighed to obtain the average dry fry weight per replicate.

STATISTICS

Survival data from the Fathead minnow test was analysed using the Student's T-Test. The Student's T-Test compares the mean of each concentration to a control mean to determine significant differences in survival. The T-Test was the most appropriate test to use considering the nature of the data, i.e. at least one concentration has zero variance. Differences in growth were analysed for statistical significance using the Dunnett's test. This test assumes a normal distribution of data and homogenous variance among treatments. Like the T-Test, Dunnett's test compares the mean of each concentration to the control mean and evaluates statistical significances, if any.

For the Ceriodaphnid test a visual data review of the survival numbers indicated that there was no differences between the control and any of the concentrations. Reproduction data was analysed by using the Dunnett's test.

The No Observable Effect Concentration (NOEC) and the Lowest Observable Effect Concentration (LOEC) were calculated on all survival, growth and/or reproduction data as applicable. The NOEC is the highest concentration of the effluent at which no adverse effect is observed. The LOEC is the lowest concentration of the effluent at which an adverse effect is observed. A Chronic Value (ChV) was also calculated for the most sensitive end point, as the geometric mean between the NOEC and the LOEC.

REFERENCE TOXICANT TESTING

Reference toxicants are commonly used to establish the validity of toxicity data. Organisms are serving as "monitors" of toxic components and therefore ranges should be established. Factors affecting organism response to a given toxicant include age, genetic strain, holding and handling procedures, test temperature, feeding regime where applicable, etc.

IT conducts acute and chronic reference toxicant tests every month on all organisms cultured in house. Every lot of organisms purchased from outside is also subject to the appropriate reference toxicant test. For fathead minnows and Ceriodaphnids, Sodium Dodecyl Sulfate (SDS) is the most commonly used reference toxicant. Results of IT Corporation's most recent acute and chronic reference toxicant tests for C. dubia and P. promelas are available upon request.

RESULTS

Following seven days of exposure of fathead fry to the effluent, an LC50 of 92.9% of effluent is reported. A survival NOEC of 50% and an LOEC of 100% is also reported. Analysis of the growth data indicates an NOEC of 100% and an LOEC of greater than 100%.

Survival data from the Ceriodaphnid test indicates an LC50 of greater than 100% . Accordingly an NOEC of 100% and an LOEC of greater than 100% is reported for survival in the ceriodaphnid test. Analysis of the reproduction results indicate an NOEC of 50% and an LOEC of 100%.

The Chronic Value for both organisms was determined to 70.7% of effluent.

NJPDES BIOMONITORING REPORT FORM - CHRONIC BIOASSAYS

Permit No. NA DSN: NA

Facility Name: O'Brien & Gere

Facility Location: Combe Fill South Landfill

Laboratory / Investigators: International Technology Corporation

A. Khan, D. Duh, G. Balog, D. Kent

Laboratory Certification No. 12064

Bioassay Specifications:

Effluent type (e.g., final, prechlorination, etc.): Treatability Test effluent

Test Type: Static ____ Renewal(6hr) . Renewal(24hr) X Flow-through ____

Test Duration(hours): 24 ____ 48 ____ 96 ____ Other (specify) 7 days

Test Organism: FATHEAD MINNOW ; PIMEPHALES PROMELAS

(common name) (scientific name)

Test Endpoint: LC50 X EC50 ____ Other (specify) NOEC, LOEC

Summary of Final Results:

Test Starting Date : 09-20-89 Completion Date : 09-27-89

Most sensitive effect : Survival

NOEC 50 LOEC 100 ChV 70.7

Quality Control Summary:

Control Mortality: 6.7% percent

Average dry weight of control organisms at least 0.25 mg? Yes X No ____

Temperature maintained within +/- 1 ^{o}C of test temperature? Yes X No ____

Dissolved Oxygen Levels always greater than 40% saturation? Yes X No ____

Loading factor for all exposed chambers less than or equal to maximum allowed for the type and temperature? Yes X No ____

Two or more concentrations exhibit a trend deviation? Yes ____ No X

Certification:

Accuracy of report certified by : David J Kent 10/10/89

Laboratory Manager Date

Test Organism Data:

Test Organism Source:

Cultured (check) X Commercial Hatchery (specify)

Test Organism Acclimation to Dilution Water :

Initial number of eggs placed in acclimation: 300

Total acclimation period of eggs/larvae: 4 days, 0 hours

Acclimation period of egg/larvae in 100% dilution water at specified test temperature: 96 hours

Test Organism Age at Start of Test (hours) < 24

Test Design:

Number of Effluent Test Concentrations (minimum of 5) 5

Number of Replicates / Test Concentration 3

Number of Test Organisms / Replicate 10

Volume of Test Chambers (milliliters) 500

Flow-through Bioassay Exchange Rate NA (cycles/day)

Effluent Sampling:

Plant Sampling Location: Treatability Test Tap

Treatment Plant Retention Time (hours): NA

Type of Sample: Grab: X 6 hr. composite 24 hr. composite Continuous feed

Sample Collection:
Beginning date: 09-11-89

Ending date: 09-11-89

If composite sample, number of grab samples in a composite NA

interval betwwen grab samples (minutes) NA

Maximum Sample Holding Time (days): 17

Test Location: On-site Remote Laboratory X

Dilution Water:

Effluent Receiving Water: Trout Brook

Dilution Water Source: Round Valley Reservoir, Lebanon, NJ

(if reconstituted water is used specify type)

If a substitute dilution water (i.e. not the receiving water) was used, has its use been approved by NJPDES? Yes X No

Collection Location: From boat launching ramp at Round Valley Reservoir

Collection Date(s): 09-01-89 ; 09-10-89

Summary Data

	Test Concentration (Percent Effluent)					
	Control	6.25	12.5	25	50	100
Percent Survival	93.3	96.7	93.3	86.7	76.7	46.7
Average Dry Weight	0.321	0.336	0.355	0.337	0.361	0.347

Bioassay Results:

LC1 ________ LC5 ________ LC10 ________ LC50 92.9

IC1 ________ IC5 ________ IC10 ________ IC50 ________

Calculation Method: Non Linear Interpolation

Survival NOEC 50 LOEC 100

Growth NOEC 100 LOEC > 100

Calculation Method: Student's T-Test (Survival) ; Dunnett's Test (Growth)

Chronic Value (ChV) 70.7

Does the data satisfy the statistical assumption of the specified calculation method? Yes X No ________

Are the calculated values valid according to the specifications of the methods used? Yes X No ________

Miscellaneous:

Was test organism stress observed during the test? Yes ________ No X

If yes, specify concentrations and abnormalities:

Were any exposure chambers aerated during the test? Yes X No ________

If yes, specify concentrations and duration: All test chambers aerated on first day when DO levels approached 60 % saturation.

Were any adjustments made to the effluent? Yes ________ No X

If yes, specify type of adjustments and methods used:

DATA FORM FOR THE FATHEAD MINNOW LARVAL SURVIVAL AND GROWTH TEST
ROUTINE CHEMICAL AND PHYSICAL DETERMINATIONS

Industry/Toxicant: O'Brien & Gere
Location: Combe Fill South Landfill
Analysts: A. Khan, D. Duh

Effluent Serial Number: NA
Permit Number: NA
Test Organism: P. promelas
Test Temperature Range: 25+/-1 C

Test Type: 7-Day Daily Renewal
Beginning Date & Time: 9/20/89 12:00 pm
Ending Date & Time: 9/27/89 12:00 pm

Control:		DAY 1	2	3	4	5	6	7	Remarks
Temperature (init)		25.5	26.0	26.0	25.0	25.5	26.0	25.5	
D.O.	Initial	7.5	7.4	7.3	8.3	8.2	8.2	8.0	
	Final	6.9	6.5	6.7	7.0	6.9	6.8	6.6	
pH	Initial	7.50	7.45	7.50	7.61	7.60	7.75	7.85	
	Final	7.05	7.20	7.50	7.55	7.60	7.60	7.70	
Alkalinity (init)		40							
Hardness (init)		50							
Conductivity(init)		160	150	150	155	150	160	170	
Chlorine (init)		0							

Conc.: 6.25%		DAY 1	2	3	4	5	6	7	
Temperature (init)		25.5	26.0	26.0	25.0	25.5	26.0	26.0	
D.O.	Initial	7.6	7.5	7.4	8.9	8.3	8.0	8.1	
	Final	6.8	6.5	7.1	6.8	6.9	6.8	6.6	
pH	Initial	7.55	7.65	7.75	7.71	7.70	7.70	7.75	
	Final	7.50	7.60	7.75	7.80	7.75	7.60	7.70	
Alkalinity (init)									
Hardness (init)									
Conductivity(init)		300	300	300	385	380	390	380	
Chlorine (init)									

DATA FORM FOR THE FATHEAD MINNOW LARVAL SURVIVAL AND GROWTH TEST
ROUTINE CHEMICAL AND PHYSICAL DETERMINATIONS (continued)

Industry/Toxicant: O'Brien & Gere
Location: Combe Fill South Landfill
Analysts: A. Khan, D. Duh

Effluent Serial Number: NA
Permit Number: NA
Test Organism: P. promelas
Test Temperature Range: 25+/-1 C

Test Type: 7-Day Daily Renewal
Beginning Date & Time: 9/20/89 12:00 pm
Ending Date & Time: 9/27/89 12:00 pm

Conc.: 25 %		DAY 1	2	3	4	5	6	7	Remarks
Temperature (init)		25.5	26.0	26.0	25.5	25.5	26.0	25.5	
D.O.	Initial	7.8	7.5	7.4	7.5	7.6	7.5	7.2	
	Final	6.9	6.3	7.9	9.1	6.8	6.9	6.7	
pH	Initial	7.90	8.10	8.20	8.07	8.15	8.20	8.25	
	Final	8.30	8.35	7.85	7.80	7.95	8.05	8.10	
Alkalinity (init)									
Hardness (init)									
Conductivity(init)		800	800	800	750	800	800	800	
Chlorine (init)									

Conc.: 100 %		DAY 1	2	3	4	5	6	7	
Temperature (init)		25.5	26.0	26.0	25.5	25.5	26.0	25.5	
D.O.	Initial	8.2	7.9	7.7	7.2	7.3	7.5	7.9	
	Final	7.0	6.2	7.4	9.0	8.0	6.9	7.2	
pH	Initial	7.95	8.30	8.35	8.40	8.45	8.50	8.45	
	Final	8.75	8.40	8.25	8.45	8.35	8.45	8.30	
Alkalinity (init)		550							
Hardness (init)		350							
Conductivity(init)		2600	2700	2650	2750	2700	2700	2650	
Chlorine (init)		0							

DATA FORM FOR THE FATHEAD MINNOW LARVAL SURVIVAL AND GROWTH TEST

SURVIVAL DATA

Industry/Toxicant: O'Brien & Gere
Location: Combe Fill South Landfill
Analysts: A. Khan, D. Duh

Effluent Serial Number: NA
Permit Number: NA
Test Organism: P. promelas
Test Temperature Range: 25+/-1 C

Test Type: 7-Day Daily Renewal
Beginning Date & Time: 9/20/89 12:00 pm
Ending Date & Time: 9/27/89 12:00 pm

Conc.:	Rep. No.	Number of Survivors DAY 1	2	3	4	5	6	7	Remarks
Control	A	10	10	10	10	10	10	10	
	B	10	10	10	10	10	10	10	
	C	10	10	10	10	10	10	8	
Conc: 6.25 %	A	10	10	10	10	10	10	10	
	B	10	10	10	9	9	9	9	
	C	10	10	10	10	10	10	10	
Conc: 12.5 %	A	10	10	10	9	9	9	9	
	B	10	10	10	9	9	9	9	
	C	10	10	10	10	10	10	10	
Conc: 25 %	A	10	10	10	9	9	9	9	
	B	10	10	10	10	10	10	9	
	C	10	10	10	10	8	8	8	
Conc: 50 %	A	10	10	10	9	7	7	7	
	B	10	10	10	10	10	9	9	
	C	10	10	10	9	9	7	7	
Conc: 100 %	A	10	10	10	9	6	6	6	
	B	10	10	10	6	6	6	6	
	C	9	9	9	6	2	2	2	
Daily Chamber Temp		26	26	26.5	26.5	26.5	26	25	
		26	26	26.5	26.5	26.5	26	25	
Daily Feeding Time		9:30 am	10:00 am	10:00 am	9:30 am	9:30 am	8:30 am		
		2:00 pm	2:30 pm	2:00 pm	2:30 pm	2:30 pm	2:30 pm		
		6:00 pm	6:00 pm	7:00 pm	7:00 pm	7:00 pm	7:00 pm		

WEIGHT DATA FOR FATHEAD MINNOW SURVIVAL AND GROWTH TEST

Industry/Toxicant: O'Brien & Gere
Location: Combe Fill South Landfill

Effluent Serial Number: NA
Permit Number: NA
Analysts: A. Khan, D. Duh

Test Type: 7-Day Daily Renewal
Beginning Date & Time: 9/20/89 12:00 pm
Ending Date & Time: 9/27/89 12:00 pm
Test Organism: P. promelas
Test Temperature Range: 25+/-1 C

Conc:	Rep. No.	A Wgt. of boat (mg)	B Dry wgt: foil and larvae (mg)	B-A Total dry wgt of larvae (mg)	C No. of larvae	(B-A)/C Mean dry wgt of larvae (mg)	Remarks
Control	A	1291.11	1294.58	3.47	10	0.347	
	B	1290.86	1293.78	2.92	10	0.292	
	C	1271.19	1273.77	2.58	8	0.322	
Conc:6.25%	A	1318.45	1321.59	3.14	10	0.314	
	B	1303.44	1306.77	3.33	9	0.370	
	C	1298.82	1302.05	3.23	10	0.323	
Conc:12.5%	A	1314.01	1316.53	2.52	9	0.280	
	B	1273.37	1276.44	3.07	9	0.341	
	C	1278.88	1283.32	4.44	10	0.444	
Conc:25.0%	A	1268.22	1271.36	3.14	9	0.349	
	B	1264.39	1267.56	3.17	9	0.352	
	C	1251.93	1254.41	2.48	8	0.310	
Conc:50.0%	A	1297.37	1300.15	2.78	7	0.397	
	B	1307.76	1311.04	3.28	9	0.364	
	C	1295.60	1297.86	2.26	7	0.323	
Conc:100 %	A	1335.27	1337.63	2.36	6	0.393	
	B	1295.14	1297.34	2.20	6	0.367	
	C	1281.91	1282.47	0.56	2	0.280	

SUMMARY DATA FOR FATHEAD MINNOW LARVAL SURVIVAL AND GROWTH TEST

Industry/Toxicant: O'Brien & Gere
Location: Combe Fill South Landfill

Effluent Serial Number: NA
Permit Number: NA
Analysts: A. Khan, D. Duh

Test Type: 7-Day Daily Renewal
Beginning Date & Time: 9/20/89 12:00 pm
Ending Date & Time: 9/27/89 12:00 pm
Test Organism: P. promelas
Test Temperature Range: 25+/-1 C

Treatment	Control	6.25	12.5	25	50	100
No. live larvae	28	29	28	26	23	14
Survival (%)	93.3	96.7	93.3	86.7	76.7	46.7
Mean dry wgt of larvae (mg +/- SD	0.321 +/- 0.0275	0.336 +/- 0.0301	0.355 +/- 0.0829	0.337 +/- 0.0234	0.361 +/- 0.0371	0.347 +/- 0.0592
Temperature Range (|C)	25.0 to 26.0	25.0 to 26.0		25.5 to 26.0		25.5 to 26.0
Dissolved oxygen range (mg/L)	6.5 to 8.3	6.5 to 8.9		6.3 to 9.1		6.2 to 9.0
Hardness range	50 to 50					350 to 350
Alkalinity range	40 to 40					550 to 550
Conductivity range	150 to 170	300 to 390		750 to 800		2600 to 2750
pH range	7.05 to 7.85	7.50 to 7.80		7.80 to 8.35		7.95 to 8.75

Comments :

NJPDES BIOMONITORING REPORT FORM - CHRONIC BIOASSAYS

Permit No. NA DSN NA

Facility Name: O'Brien and Gere

Facility Location: Combe Fill South Landfill

Laboratory / Investigators: International Technology Corporation

G. BALOG, D. DUH, D. KENT, A. KHAN

Laboratory Certification No. 12064

Bioassay Specifications:

Effluent type (e.g.,final,prechlorination): Treatability Test Effluent

Test Type: Static ____ Renewal(6hr) ____ Renewal(24hr) X Flow-through ____

Test Duration(hours): 24 ____ 48 ____ 96 ____ Other (specify) 7 days

Test Organism: WATER FLEA ; CERIODAPHNIA DUBIA

(common name) (scientific name)

Test Endpoint: LC50 X EC50 ____ Other (specify) NOEC , LOEC

Summary of Final Results:

Test Starting Date : 9-20-89 Completion Date : 9-28-89

Most sensitive effect : Reproduction

NOEC 50% LOEC 100% ChV 70.7%

Quality Control Summary :

Control Mortality : 0 percent

Temperature maintained within +/- 1 ^{o}C of test temperature? Yes X No ____

Dissolved Oxygen Levels always greater than 60% saturation? Yes X No ____

Loading factor for all exposed chambers less than or equal to maximum allowed for the type and temperature? Yes X No ____

Two or more concentrations exhibit a trend deviation? Yes ____ No X

Certification :

Accuracy of report certified by: David J Kent 10/10/89

Laboratory Manager Date

Test Organism Data :

Test Organism Source:

Cultured (check) X Commercial Hatchery (specify) ______

Test Organism Acclimation to Dilution Water :

Initial Number of Adult Organisms 100 Total Acclimation Period: NA* days, ______

Acclimation Period in 100 percent dilution water at the specified test temperature : NA* hours

Number of Mortalities (48 hours prior to test) 0 * organisms cultured in test diluent

Test Organism Age at Start of Test (hours) 16 - 20

Test Design :

Number of Effluent Test Concentrations (minimum Of 5) 5

Number of Replicates / Test Concentration 10

Number of Test Organisms / Replicate 1

Volume of Test Chambers (liters) 15 ml

Flow-through Bioassay Exchange Rate NA (cycles/day)

Effluent Sampling:

Plant Sampling Location : Treatability Test Tap

Treatment Plant Retention Time (hours) : NA

Type of Sample : Grab X 6 hr. composite ______ 24 hr. composite ______ Continuous feed ______

Sample Collection :
Beginning date : 9-11-89

Ending date : 9-11-89

If composite sample , number of grab samples in a composite NA;

interval between grab samples (minutes) : NA

Maximum Sample Holding Time (days) : 17

Testing Location : On-site ______ Remote Laboratory X

Dilution Water :

Effluent Receiving Water : Trout Brook

Dilution Water Source : Round Valley Reservoir, Lebanon, NJ

(if reconsituted water is used specify type)

If a substitute dilution water (i.e. not the receiving water) was used , has its use been approved by NJPDES ? Yes X No ______

Collection Location : From boat launching ramp at Round Valley Reservoir

Collection Date (s) : 9-1-89 ; 9-10-89

Summary data

Test Concentration (Percent Effluent)

	Control	6.25	12.5	25	50	100
Percent Survival	100%	100%	100%	100%	100%	100%
Average Young per Live Adult	16.2	16.7	14.0	15.2	13.0	7.5

Bioassay Results:

LC1	LC5	LC10	LC50 >100%
IC1	IC5	IC10	IC50 93.1%

Calculation Method : Visual Data Review (survival) ; Nonlinear Interpolation (Reproduction)

Survival	NOEC 100%	LOEC >100%
Reproduction	NOEC 50%	LOEC 100%

Calculation Method : Reproduction(Dunnett's Test) Survival(Visual Data Review)

Chronic Value (ChV) 70.7%

Does the data satisfy the statistical assumption of the specified calculation methods? Yes X No

Are the calculated values valid according to the specifications of the methods used? Yes X No

Miscellaneous :

Was test organism stress observed during the test? Yes No X

If yes, specify concentrations and abnormalities:

Was aeration necessary during the test? Yes No X

If yes, specify when and methods used:

Were any adjustments made to the effluent? Yes No X

If yes, specify type of adjustments and methods used:

DATA FORM FOR CERIODAPHNIA SURVIVAL AND REPRODUCTION TEST — DAILY SURVIVAL

Industry/Toxicant: O'Brien and Gere
Location: Combe Fill South Landfill
Analysts: A. Khan, D. Duh

Effluent Serial Number: NA
Permit Number: NA
Test Organism: Ceriodaphnia dubia
Test Temperature Range: 25+/-1 C

Test Type: 8-day daily renewal
Beginning Date & Time: 9-20-89 12:00 pm
Ending Date & Time: 9-28-89 12:00 pm

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	TOTAL
Control	1	1	1	1	1	1	1	1	1	1	1	10
	2	1	1	1	1	1	1	1	1	1	1	10
	3	1	1	1	1	1	1	1	1	1	1	10
	4	1	1	1	1	1	1	1	1	1	1	10
	5	1	1	1	1	1	1	1	1	1	1	10
	6	1	1	1	1	1	1	1	1	1	1	10
	7	1	1	1	1	1	1	1	1	1	1	10
	8	1	1	1	1	1	1	1	1	1	1	10

FINAL TOTAL LIVE ADULTS AT TEST COMPLETION | 10

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	TOTAL
25%	1	1	1	1	1	1	1	1	1	1	1	10
	2	1	1	1	1	1	1	1	1	1	1	10
	3	1	1	1	1	1	1	1	1	1	1	10
	4	1	1	1	1	1	1	1	1	1	1	10
	5	1	1	1	1	1	1	1	1	1	1	10
	6	1	1	1	1	1	1	1	1	1	1	10
	7	1	1	1	1	1	1	1	1	1	1	10
	8	1	1	1	1	1	1	1	1	1	1	10

FINAL TOTAL LIVE ADULTS AT TEST COMPLETION | 10

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	TOTAL
6.25%	1	1	1	1	1	1	1	1	1	1	1	10
	2	1	1	1	1	1	1	1	1	1	1	10
	3	1	1	1	1	1	1	1	1	1	1	10
	4	1	1	1	1	1	1	1	1	1	1	10
	5	1	1	1	1	1	1	1	1	1	1	10
	6	1	1	1	1	1	1	1	1	1	1	10
	7	1	1	1	1	1	1	1	1	1	1	10
	8	1	1	1	1	1	1	1	1	1	1	10

FINAL TOTAL LIVE ADULTS AT TEST COMPLETION | 10

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	TOTAL
50%	1	1	1	1	1	1	1	1	1	1	1	10
	2	1	1	1	1	1	1	1	1	1	1	10
	3	1	1	1	1	1	1	1	1	1	1	10
	4	1	1	1	1	1	1	1	1	1	1	10
	5	1	1	1	1	1	1	1	1	1	1	10
	6	1	1	1	1	1	1	1	1	1	1	10
	7	1	1	1	1	1	1	1	1	1	1	10
	8	1	1	1	1	1	1	1	1	1	1	10

FINAL TOTAL LIVE ADULTS AT TEST COMPLETION | 10

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	TOTAL
12.5%	1	1	1	1	1	1	1	1	1	1	1	10
	2	1	1	1	1	1	1	1	1	1	1	10
	3	1	1	1	1	1	1	1	1	1	1	10
	4	1	1	1	1	1	1	1	1	1	1	10
	5	1	1	1	1	1	1	1	1	1	1	10
	6	1	1	1	1	1	1	1	1	1	1	10
	7	1	1	1	1	1	1	1	1	1	1	10
	8	1	1	1	1	1	1	1	1	1	1	10

FINAL TOTAL LIVE ADULTS AT TEST COMPLETION | 10

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	TOTAL
100%	1	1	1	1	1	1	1	1	1	1	1	10
	2	1	1	1	1	1	1	1	1	1	1	10
	3	1	1	1	1	1	1	1	1	1	1	10
	4	1	1	1	1	1	1	1	1	1	1	10
	5	1	1	1	1	1	1	1	1	1	1	10
	6	1	1	1	1	1	1	1	1	1	1	10
	7	1	1	1	1	1	1	1	1	1	1	10
	8	1	1	1	1	1	1	1	1	1	1	10

FINAL TOTAL LIVE ADULTS AT TEST COMPLETION | 10

DATA FORM FOR CERIODAPHNIA SURVIVAL AND REPRODUCTION TEST — DAILY REPRODUCTION

Industry/Toxicant: O'Brien and Gere
Location: Combe Fill South Landfill
Analysts: A. Khan, D. Duh

Effluent Serial Number: NA
Permit Number: NA
Test Organism: Ceriodaphnia dubia
Test Temperature Range: 25+/-1 C

Test Type: 8-day daily renewal
Beginning Date & Time: 9-20-89 12:00 pm
Ending Date & Time: 9-28-89 12:00 pm

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	AVERAGE YOUNG PER LIVE ADULT
Control	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	3	0	0	0	0	0	0	
	4	5	1	3	2	0	2	2	0	0	1	
	5	2	3	2	3	2	2	0	3	3	2	
	6	0	1	4	1	3	0	2	3	2	0	
	7	4	5	2	3	5	5	6	4	5	4	
	8	4	5	6	10	8	4	6	6	8	5	
SUM/LIVE ADULT		15	15	17	22	18	13	16	16	18	12	16.20

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	AVERAGE YOUNG PER LIVE ADULT
25%	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	2	0	4	3	0	2	1	3	2	
	5	3	0	3	0	3	0	3	0	0	0	
	6	7	0	5	7	5	4	2	0	0	0	
	7	2	6	0	1	2	5	4	6	4	5	
	8	8	4	8	6	7	7	5	6	3	4	
SUM/LIVE ADULT		20	12	16	18	20	16	16	13	10	11	15.20

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	AVERAGE YOUNG PER LIVE ADULT
.25%	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	1	3	4	0	2	3	0	2	0	0	
	5	1	3	3	3	3	0	2	5	3	3	
	6	2	3	4	2	4	0	4	2	4	2	
	7	5	3	2	4	3	5	4	3	4	6	
	8	8	9	6	6	7	4	6	3	6	5	
SUM/LIVE ADULT		17	21	19	15	19	12	16	15	17	16	16.70

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	AVERAGE YOUNG PER LIVE ADULT
50%	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	5	0	0	3	1	0	0	2	0	0	
	5	1	0	3	0	0	3	3	1	2	0	
	6	0	0	0	3	0	7	0	4	6	2	
	7	4	3	3	3	5	0	4	2	3	4	
	8	9	5	3	8	10	2	3	3	2	8	
SUM/LIVE ADULT		19	8	9	17	16	12	10	12	13	14	13.00

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	AVERAGE YOUNG PER LIVE ADULT
2.5%	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	2	2	0	1	0	0	1	3	0	2	
	5	0	0	1	3	3	3	2	0	3	0	
	6	0	0	0	3	2	4	4	0	3	0	
	7	4	5	4	3	4	0	5	6	0	7	
	8	4	6	5	8	7	7	7	4	8	4	
SUM/LIVE ADULT		10	13	10	18	16	14	19	13	14	13	14.00

CONC.	DAY	REPLICATE 1	2	3	4	5	6	7	8	9	10	AVERAGE YOUNG PER LIVE ADULT
100%	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	1	0	0	3	0	1	1	0	2	1	
	5	0	0	0	0	0	0	0	0	3	0	
	6	0	6	0	6	0	3	0	0	4	6	
	7	3	0	2	0	3	1	4	0	0	2	
	8	2	6	1	1	2	0	5	0	1	5	
SUM/LIVE ADULT		6	12	3	10	5	5	10	0	10	14	7.50

DATA FORM FOR CERIODAPHNIA SURVIVAL AND REPRODUCTION TEST PHYSICAL & CHEMICAL DETERMINATIONS

Industry/Toxicant: O'Brien and Gere
Location: Combe Fill South Landfill
Analysts: A. Khan, D. Duh

Effluent Serial Number: NA
Permit Number: NA
Test Organism: Ceriodaphnia dubia
Test Temperature Range: 25+/-1 C

Test Type: 8-day daily renewal
Beginning Date & Time: 9-20-89 12:00 pm
Ending Date & Time: 9-28-89 12:00 pm

Control:		Day 1	2	3	4	5	6	7	8	Remarks
Temperature (init)		25.5	26.0	25.5	25.0	25.5	26.0	25.5	25.0	
D.O.	Initial	7.5	7.4	7.4	7.3	8.2	8.2	8.0	7.8	
	Final	7.0	7.2	7.2	6.8	6.9	6.8	7.0	6.9	
pH	Initial	7.50	7.45	7.70	7.53	7.60	7.75	7.85	7.75	
	Final	7.40	7.83	7.42	7.50	7.60	7.60	7.70	7.75	
Alkalinity (init)		40	50	50	50	40	40	40	50	
Hardness (init)		60	70	60	70	60	50	70	60	
Conductivity(init)		160	150	170	150	150	160	170	160	
Chlorine (init)		0								

Conc.: 6.25%		Day 1	2	3	4	5	6	7	8	Remarks
Temperature (init)		25.5	26.0	25.5	25.0	25.5	26.0	26.0	25.0	
D.O.	Initial	7.6	7.5	7.4	7.7	8.3	8.0	8.1	7.8	
	Final	6.8	7.5	7.6	6.9	6.9	6.8	7.0	6.9	
pH	Initial	7.55	7.65	8.04	7.78	7.70	7.70	7.75	7.80	
	Final	7.50	8.06	7.51	7.55	7.75	7.60	7.70	7.75	
Alkalinity (init)		60	60	70	50	60	60	60	50	
Hardness (init)		70	70	60	80	100	100	80	80	
Conductivity(init)		300	300	290	300	380	390	380	390	
Chlorine (init)										

	1	2	3	4	5	6	7	8	9
DAILY TEMP. READINGS	25.5	25.5	26.0	26.5	25.5	25.5	25.5	26.0	
	25.5	26.0	26.0	25.5	26.0	26.0	26.5		

DATA FORM FOR CERIODAPHNIA SURVIVAL AND REPRODUCTION TEST

Industry/Toxicant: O'Brien and Gere
Location: Combe Fill South Landfill
Analysts: A. Khan, D. Duh

Effluent Serial Number: NA
Permit Number: NA
Test Organism: Ceriodaphnia dubia
Test Temperature Range: 25+/-1 C

Test Type: 8-day daily renewal
Beginning Date & Time: 9-20-89 12:00 pm
Ending Date & Time: 9-28-89 12:00 pm

Conc.: 25%		Day 1	2	3	4	5	6	7	8	Remarks
Temperature (init)		25.5	26.0	25.5	25.0	25.5	26.0	25.5	25.0	
D.O.	Initial	7.8	7.5	7.5	7.7	7.6	7.5	7.2	7.7	
	Final	6.9	7.6	7.6	7.0	6.8	6.9	7.1	7.0	
pH	Initial	7.90	8.10	8.32	8.18	8.15	8.20	8.25	8.15	
	Final	8.30	8.38	7.69	7.65	7.95	8.05	8.05	8.00	
Alkalinity (init)		130	120	130	100	150	144	150	130	
Hardness (init)		130	150	170	160	150	160	160	150	
Conductivity(init)		800	800	700	700	800	800	800	800	
Chlorine (init)										

Conc.: 100%		Day 1	2	3	4	5	6	7	8	Remarks
Temperature (init)		25.5	26.0	25.5	25.0	25.5	26.0	25.5	25.0	
D.O.	Initial	8.2	7.9	7.9	7.8	7.3	7.5	7.9	7.6	
	Final	7.0	8.0	7.9	6.8	8.0	6.9	7.2	7.0	
pH	Initial	7.95	8.30	8.51	8.32	8.45	8.50	8.45	8.20	
	Final	8.75	8.66	8.43	8.40	8.35	8.45	8.40	8.10	
Alkalinity (init)		530	510	530	450	450	376	510	500	
Hardness (init)		350	330	350	330	350	300	310	320	
Conductivity(init)		2600	2700	2500	2500	2700	2700	2650	2700	
Chlorine (init)		0								